


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7/25/68

THE PLANNING OF CLINICAL FACILITIES
FOR MEDICAL EDUCATION: A SYSTEMS APPROACH

A THESIS

Presented to

The Faculty of the Division of Graduate
Studies and Research

by

James Bailey Mathews

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FOR MEDICAL EDUCATION: A SYSTEMS APPROACH

Approved:

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SUMMARY

The general purposes of this study were to investigate the process of planning clinical facilities for medical education through the systems approach, and to investigate the applicability of management science principles, approaches, and techniques in this process. The following specific objectives were established:

1. The development of a description and conceptualization of the process of planning for clinical facilities for medical education.
2. An investigation of the applicability and practicability of management science principles and techniques through an analysis of the planning decision process, and the development of examples of the application of management science techniques.
3. The identification of promising and important areas of the planning process which require further research and development regarding the application of management science.

This investigation was aimed at the process of planning for clinical facilities within the framework of a health-education institution, e.g., a medical college. It was directed primarily toward those planning decisions and problems which have more or less direct implications for certain major managerial and operational features of facility plans and designs, such as quantities of facilities and operational designs.

The process of planning for clinical education facilities was investigated firsthand by participating in planning for a new clinical services building at the Medical College of Georgia in Augusta. Observations of the project at the Medical College of Georgia were augmented by accounts of other planning for similar projects reported in the literature and by discussions with professional people working in this field. Another primary source of information and insights was corporate and managerial planning literature. An attempt was made to select portions of the findings from this field of planning which seemed general in nature and which were relevant and applicable to the planning process under study.

Based upon the information obtained from the sources described above, the process of planning for clinical education facilities and the managerial environment in which it is performed were conceptualized and described. This step was performed in a manner which identified the major elements of planning and their interactions, and which indicated the major characteristics of the planning process with emphasis upon those relevant to the potential application of management science.

Using the conceptual description as a base, the potential applicability and practicability of management science principles and techniques were reviewed. This review includes a discussion of such things as the nature of the decisions involved, timing requirements, availability of data, and managerial acceptance. Several critical factors which affect the practicability of the use of management science in this process were described, and the most promising forms of management science contribution to this process were identified and discussed.

Illustrative examples were developed.

Finally, all of the above surveys, descriptions, and analyses were used to identify promising and important areas of this planning process which require further research and development regarding the application of management science.

CHAPTER I

INTRODUCTION

Purpose

The general purposes of this study are to investigate the process of planning clinical facilities for medical education through the systems approach, and to investigate the applicability of management science principles, approaches, and techniques in this process. As used herein, the term "systems approach" means an approach which involves identifying and describing each stage (component) of a process (system) and determining the relationships among the stages, including the inputs and outputs for each stage, so that the functioning of the total process (system) relative to its environment can be understood. The term "management science" refers to the body of scientifically verifiable knowledge related to management, and to the application of scientific techniques and approaches in the study of managerial decision situations, the execution of the managerial function, and the solution of managerial problems. In this study special emphasis is placed upon modern industrial engineering and operations research as representing the field of management science.

The author's interest in this subject stemmed initially from involvement in an actual facilities planning project at the Medical College of Georgia in Augusta, Georgia. Experience in this project revealed a need and significant potential for the application of

management science in the planning process, but it also made clear the many difficulties and complexities involved in bringing these principles, approaches, and techniques to bear in such a dynamic, loosely structured, and poorly understood process. Furthermore, a review of the literature revealed that the planning of clinical facilities for medical education to date has been essentially devoid of the use of management science except for certain limited operational aspects of facilities design. The conventional planning approaches involve primarily intuition, judgment, rules of thumb, and trials and errors in planning at other locations, combined with architectural practice involving an artful blending of creativity and standard solutions.

Interest in this general subject was further strengthened by the apparent strong need for management scientists to devote more attention to the application of their discipline in various fields of planning. It has been pointed out that management science has not begun to meet the challenge of planning and the development of planning models. Its achievements are primarily in the areas of policy and control involving short-range and repetitive operations.¹ These points are further emphasized by the following:

It turns out that what management needs in planning models has little counterpart in what has been delivered. With a few notable exceptions, planning relates to a class of models that is least familiar in practice to management scientists. Of course, through one ploy or another, almost any existing management science model could be shown to embody vital elements of the planning function.

¹Starr, Martin K., "Planning Models," *Management Science*, Vol. 13, No. 4, Dec. 1966, pp. B115-B141.

. . . No matter how you view it, the need for planning models is far more striking than their degree of development. They are in an incipient stage and there should be no wish to mask that fact.

Part of the explanation for this state of affairs rests with management scientists and their lack of involvement in planning for the enterprise. Management has also played its part by resisting the incursion of scientific method into the inner sanctum of the upper-management planning function. Yet there is general concurrence about the importance of the planning function, and a growing opinion that any change in the roles and relationships just described must be motivated by increased mutual understanding.²

The economic importance of the planning problem is reflected in projections of the increasing need for clinical facilities for medical education. The recent "Report on the National Advisory Commission on Health Manpower"³ projected a growing shortage of health manpower in the United States, indicating a need for substantial increases in clinical-teaching facilities. As an example of this need, it was estimated that the number of students in entering classes in medical schools would have to increase by approximately two-fold by 1975 "if the present inadequate ratio of medical school spaces to bachelor degrees is to be maintained."⁴ Another publication entitled "Developing Medical Schools: An Interim Report"⁵ indicates that nine new medical schools are expected to be established between 1968 and 1971,

²*Ibid.*, pp. B116-7.

³"Report of the National Advisory Commission on Health Manpower," Vol. 1, U.S. Government Printing Office, November 1967, 93 pp.

⁴*Ibid.*, p. 17.

⁵Smythe, Cheves McC., "Developing Medical Schools: An Interim Report," *The Journal of Medical Education*, Vol. 42, No. 11, November 1967, pp. 991-1004.

but even this rate of increase is not adequate to meet the demand for this kind of health manpower. Estimates on capital construction costs for clinical facilities for developing medical schools have ranged from \$155,000 to \$368,000 per entering medical student, indicating the very high cost of this type of construction.

Objectives

The following specific objectives were established as the primary elements in pursuing the general purpose of the present investigation:

1. The development of a description and conceptualization of the process of planning for clinical facilities for medical education.
2. An investigation of the applicability and practicability of management science principles and techniques through an analysis of the planning decision process, and the development of examples of the application of management science techniques.
3. The identification of promising and important areas of the planning process which require further research and development regarding the application of management science.

Scope and Limitations

This investigation is aimed at the process of planning for clinical facilities within the framework of a health-education institution, e.g., a medical college. Therefore, one of the major premises of this work is that one needs a comprehensive understanding of the managerial environment and of the modus operandi of the institution in order to evaluate the applicability of management science. Further, plans for clinical facilities must be based upon relatively comprehensive and

well-developed managerial and educational program plans.

It is assumed at the outset of this investigation that the nature and requirements of the planning process under study have much in common with, and are similar in many basic structural ways to, other fields of planning, such as corporate and business managerial planning. In the absence of adequate literature regarding the particular process being studied, insights and principles are sought in the literature of these other fields of planning.

This study is directed primarily toward those planning decisions and problems which have more or less direct implications for certain major managerial and operational features of facility plans and designs, such as quantities of facilities and operational designs. Other major aspects of the planning and design process, such as those involving esthetics, building structure, and the detailed design of individual areas, will not be discussed.

Structure of the Investigation

The process of planning for clinical-teaching facilities was investigated firsthand by participating in planning for a new clinical services building at the Medical College of Georgia in Augusta. Although this project is not yet complete, and even though it has encountered many delays, setbacks, and changes during the period of this study, it has revealed much about the nature and characteristics of this type of planning process which is relevant to the subject of this study.

Observations of the project at the Medical College of Georgia were augmented by accounts of other planning for similar projects

reported in the literature and by discussions with professional people working in this field. Another primary source of information and insight was corporate and managerial planning literature. An attempt was made to select portions of the findings from this field of planning which seemed general in nature and which were relevant and applicable to the planning process under study.

Based upon the information obtained from the sources cited above, the process of planning for clinical education facilities and the managerial environment in which it is performed were conceptualized and described. This step was performed in a manner which identified the major planning decisions and indicated the major characteristics of the planning process relevant to the potential application of management science.

Using the conceptual description as a base, the potential applicability and practicability of management science principles and techniques are reviewed. This review includes a discussion of such factors as the nature of the decisions involved, timing requirements, availability of data, and managerial acceptance. Several examples are constructed to illustrate the potential application of management science techniques to various decisions involved in the planning process.

Finally, all of the above surveys, descriptions, and analyses are used to identify promising and important areas of this planning process which require further research and development regarding the application of management science.

It will be noted that the investigation reported herein is not experimental research and is not a classical application of the scientific method. It is essentially based upon the exploration of a new field of application using the methods of survey, observation, description, and intellectual inquiry. Hopefully, this dissertation establishes a clarification or arguable view regarding the application of management science in planning for clinical facilities within an academic institution through a systematic discussion of this subject presented in essay form.

This type of investigation seems to be justified and appears to be the most needed type for the general subject area under consideration. With the present state of knowledge in this field, there is no appreciable base of available research or relevant theories. There is a need for enough insight and understanding to form hypotheses for the more specialized and scientifically structured forms of research. At this time, the priority should be on realism rather than on formalism. This view seems to be supported by writers on similar subjects in the fields of management science and planning.⁶

Results

As indicated above, the results of this investigation are a description and analysis of the planning process and its managerial

⁶For example, see:

Ansoff, H. Igor, and Richard C. Brandenburg, "A Program of Research in Business Planning," *Management Science*, Vol. 13, No. 6, February 1967, pp. B219-B239.

Drucker, Peter F., "Long-Range Planning: Challenge to Management Science," *Management Science*, Vol. 5, No. 3, April 1959, pp. 238-249.

environment; a review of the applicability and practicability of management science principles and techniques, including several examples; and the identification of areas for further investigation. These results should provide a significant contribution to the knowledge and understanding required for improved practice and research by industrial and systems engineers in this and closely related fields.

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"Report of the National Advisory Commission on Health Manpower," Vol. 1, U. S. Government Printing Office, November 1967, 93 pp.

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Starr, Martin K., "Planning Models," *Management Science*, Vol. 13, No. 4, December 1966, pp. B115-B141.

CHAPTER II

LITERATURE SURVEY: CLINICAL FACILITIES PLANNING

A survey of the literature in this field indicates that there was very little interest in the study and improvement of the planning of hospital facilities prior to the mid-1940's.¹ Beginning in the mid-1940's the Division of Hospital Facilities of the Public Health Service began to promote studies related to hospital design. These studies have dealt primarily with planning the floor space, facilities, and layouts for specific elements of the hospital.² Most of these studies are based upon an accumulation of expert judgment and experience rather than research or analytical investigation. During recent years articles on hospital planning and construction have begun to appear more frequently in hospital literature.³ While most of these articles also have dealt

¹This is confirmed by Cunningham, Robert M., Jr., "Introduction--Design and Construction of General Hospital," (Reprint of a series of articles which appeared in *The Modern Hospital* under the title, "The Functional Basis of Hospital Planning," beginning with the March 1947 issue), p. 3.

²For example, see "Elements of the General Hospital," *Hospitals*, May 1946; "The Functional Basis of Hospital Planning," *The Modern Hospital*, March 1947; "Elements of the General Hospital," *Hospitals*, April 1952; Haldeman, Jack C., "How to Plan Care Units for Patients and Staff," *The Modern Hospital*, October 1962, Vol. 99, No. 4, pp. 100-108; 146-160; "Planning the Patient Care Unit in the General Hospital," Public Health Service Publication No. 930-D-1, June 1962, 40 pp.; "General Standards of Construction and Equipment--General Hospitals," Public Health Service Publication, 1962; "Elements of Progressive Patient Care," Public Health Service Publication No. 930-C-1, September 1962, 65 pp.

³For example, see the annual Planning and Construction issue of *Hospitals*.

with experiences regarding the facilities and layout of specific areas within the hospital, some in more recent years have discussed certain "systems" within the hospital, e.g., distribution systems, communication systems, and computer systems.⁴

The passage of the Hospital Survey and Construction Act (Hill-Burton Program) in 1946 has significantly affected the field of hospital planning and design. In order to qualify for financial support for construction of new facilities or modernization of old facilities under this program the plans must conform with certain standards regarding floor space allocation, number of beds per room, nursing unit sizes, etc.⁵

One of the first studies of hospital planning and design which attempted to analyze the relationships among the various elements of the hospital as well as the elements themselves was conducted by Nuffield Provincial Hospital Trust in England in the mid-1950's.⁶ It was an experimental study of the internal functions of the hospital. This work represented a significant advance in the field and has become a standard

⁴For example, see Wertz, Frederick E., "Electronic Data Processing for Hospitals--current practices and future needs," *Hospitals*, J.A.H.A. Vol. 36, May 1, 1962; Barker, Kenneth N., "Experimental Distribution Systems Offers Total Drug Control," *Hospitals*, J.A.H.A., Vol. 39, No. 18, September 16, 1965, pp. 142, 145-6, 148, 150-2, and 155; Letourneau, Charles U., M.D., "Automated Transportation of Hospital Materials," *Hospital Management*, July 1967, pp. 40-41.

⁵"Public Health Service Regulations--Part 53; Pertaining to the Construction and Modernization of Hospital and Medical Facilities," Public Health Service Publication, 1964, 22 pp. and "Facts about the Hill-Burton Program," Public Health Service Publication, 1964, 6 pp.

⁶*Studies in the Functions and Design of Hospitals*, Nuffield Provincial Hospital Trust, Oxford University Press, London 1955.

reference. Other work in hospital planning up to this time had been concerned only with special and limited problems in hospital planning.⁷

Numerous articles and books by hospital planners, including administrators and architects, regarding special aspects of planning and designing general hospitals have been published in recent years.⁸ These publications contain facts, descriptions, and discussion related primarily to functional, operational, and technical considerations in hospital planning and operation of hospitals. They do not represent or describe a methodology for planning, nor do they discuss possible techniques for planning such as those of management science. In general they provide information from the current body of knowledge relative to the functional aspects of hospital facilities which should be helpful in making many of the detailed estimates, judgments, and decisions required in facilities planning and design.

A review of the proceedings of a recent institute on hospital planning conducted by The American Association of Hospital Consultants⁹

⁷Davies, R. Llewelyn and John Weeks, "Progress in Planning Hospitals," *The Journal of the Royal Institute of British Architects*, Vol. 66, No. 3, January 1959, pp. 79-92.

⁸For example, see: Rosenfield, Isadore, *Hospitals: Integrated Design*, Reinhold Publishing Corporation, New York, 1955, 308 pp.; Wheeler, E. Todd, *Hospital Design and Function*, McGraw-Hill Book Company, New York, 1964, 296 pp.; Hudenburg, Roy, *Planning the Community Hospital*, McGraw-Hill Book Company, New York, 1967, 438 pp., and Mills, Alden B. (ed.), *Functional Planning of General Hospitals* (by The American Association of Hospital Consultants), McGraw-Hill Book Company, New York, 1969, 353 pp.

⁹*Proceedings of the Hospital Trustees and Administrators Institute on Hospital Planning*, January 10-12, 1968, Atlanta, Georgia, conducted by the American Association of Hospital Consultants.

reflects a similar absence of the approach suggested in the present investigation, i.e., the systems approach and the use of the techniques of management science.

A few attempts have been made to develop analytical and quantitative techniques for use in hospital planning. Pelletier and Thompson¹⁰ developed a method of evaluating the efficiency of various nursing-unit designs by using a measure of the traffic between certain points. Freeman¹¹ attempted to extend this method by including personnel costs and construction costs. Delon and Smalley¹² incorporated Freeman's work into a more comprehensive methodology for the generation and evaluation of designs for the entire hospital. This methodology uses computerized facility-layout techniques for generating and evaluating general hospital layouts relative to qualitative considerations and constraints, as well as quantitative traffic cost data. Several other analytical studies and advances related to particular aspects of the design problem have also been reported during recent years.¹³

¹⁰Pelletier, Robert J. and John D. Thompson, "Yale Index Measures Design Efficiency," *The Modern Hospital*, November 1960, Vol. 95, No. 5, pp. 73-77.

¹¹Freeman, John R., *Quantitative Criteria for Hospital Inpatient Nursing Unit Design* (Ph.D. Dissertation), Georgia Institute of Technology, December 1967, 151 pp.

¹²Delon, Gerald L. and Harold E. Smalley, *Quantitative Methods for Evaluating Hospital Designs* (PHS Research Grant No. -HM 00529, Final Report), Program Bulletin No. 5, Program in Hospital and Medical Systems, Georgia Institute of Technology, Atlanta, Georgia, August 1969, 239 pp.

¹³For example, see Dudek, Richard A., "Proximity Relationships for a New Hospital" (A Case Study), *Hospital Industrial Engineering* (Harold E. Smalley and John R. Freeman, Authors), Reinhold Publishing

In the early 1960's a study related to the design of general hospitals was supported by the U. S. Public Health Service and jointly sponsored by the American Hospital Association and the American Institute of Architects. One report resulting from this study furnishes data from 70 hospitals and a methodology for estimating space needs and cost for the construction of general hospitals.¹⁴ A second report describes a study of interdepartmental traffic, and the use of traffic data in a computerized method for evaluating alternative designs.¹⁵

It appears that the only publication devoted primarily to the process of planning hospital facilities is the *Manual of Hospital Planning Procedures*.¹⁶ This manual contains a general discussion of planning procedures and identifies some of the major steps involved as well as the primary participants in each step, based upon traditional practice in hospital facilities planning. With regard to the objectives of the investigation described herein, it does not cover medical education considerations, it does not involve the use of quantitative methods and the principles of management science, and it does not cover

Corporation, New York, 1966; and Steiner, Mathew W., and Leon C. Pullen, "Do Automatic Materials Distribution Systems Really Save Money?", *Hospitals*, J.A.H.A., Vol. 43, No. 3, February 1, 1969, pp. 75-78.

¹⁴Souder, James J., "Estimating Space Needs and Costs in General Hospital Construction," American Hospital Association, Chicago, 1963, 32 pp.

¹⁵Souder, James J., *et al.*, "Planning for Hospitals: A Systems Approach Using Computer-Aided Techniques," American Hospital Association, Chicago 1964, 167 pp.

¹⁶*Manual of Hospital Planning Procedures*, American Hospital Association, 1966, 72 pp.

some of the important areas of facilities planning and design to which management science might be applied, such as incremental construction and other matters of economics.

Papers presented at the National Academy of Engineering's Conference on Cost of Health Care Facilities¹⁷ described the need for research and study in hospital planning. This need spans the entire process from the determination of facility needs through contracting and construction.

The standard reference regarding planning clinical facilities for medical education seems to be *Medical Education Facilities--Planning Considerations and Architectural Guide*.¹⁸ This book is based upon visits to nine teaching hospitals and a review of the literature and many plans. Its contents represent a committee consensus regarding the essentials of a good medical school facility. It presents rather detailed data as a guide for identifying and estimating certain facility requirements within the general framework of a specified level of activity and staffing.

Very few other publications relating studies and experiences in planning clinical facilities for medical education have appeared in the literature. Two papers which do report such an experience were presented at the International Congress of Teaching Hospitals, one in

¹⁷"Chairman's Report--Panel on Construction Cost of Hospitals," National Academy of Engineering, Conference on Cost of Health Care Facilities, 5-6 December 1967, 16 pp.

¹⁸*Medical Education Facilities--Planning Considerations and Architectural Guide*, U.S. Dept. of Health Education and Welfare, Public Health Service Publication No. 1180-A-1b, 185 pp.

1965¹⁹ and the other in 1967.²⁰ Both of these papers provided valuable discussion of certain concepts and aspects of design, but neither covers either the planning process itself or the application of quantitative methods.

During recent years the literature has begun to contain discussions of the complexity of medical centers and the extreme difficulty in planning and designing them. In 1965 the New York Academy of Sciences conducted a conference entitled "Medical Schools and Teaching Hospitals: Curriculum Programming and Planning."²¹ Several papers presented at this conference discussed physical programming and planning.²² All of these papers emphasized the complexity and importance of the planning process itself. This is very well summarized by the following paragraphs from the paper by Justar.

I sometimes think that the architect of today's medical center is really not that at all, but rather a new breed of specialist--

¹⁹Stephan, James W., "The Plan and Concept of the University of British Columbia Health Sciences Center Reflecting the Health Team Approach," Presented at the International Congress of Teaching Hospitals, June 1965.

²⁰Stephan, James W., "Teaching and Research Requirements in a Health Teaching Complex," Presented at the International Congress of Teaching Hospitals, August 1967.

²¹Whipple, Harold E. (Editor), "Medical Schools and Teaching Hospitals: Curriculum Programming and Planning," *Annals of the New York Academy of Science*, Vol. 128, Article 2, pp. 457-720, Sept. 27, 1965.

²²*Ibid.* For example, see "Introduction to Physical Programming and Planning," by Howard H. Justar; "Criteria for Planning" by Joseph Blumenkranz; "Teaching Facilities for Medical Education; or, Can We Have All this Plumbing and Architecture Too?" by Jonathan King; "Educational Facilities in the Hospital for Teaching," by Alan C. Green, and "Long-Range Planning of the Medical Center," by E. Todd Wheeler.

part psychiatrist and part symphony orchestra conductor. For in addition to the traditional administrative and consultant resources of the past, he must work with special medical experts, and behavioral experts; with industrial engineers, cybernetic engineers, and operating engineers; with urban planners, space planners, landscape planners and interior planners--and I've probably left out at least a half-dozen others.

Now this is all really very much to the good, for it is obvious that no one man can solve all the problems to which I have alluded, and many more besides. However, to make all this talent effective, a team effort, well directed, is an absolute necessity. If I suggest that the leader be an architect, it is merely for the sake of discussion. In any case, it is very necessary that all the specialists I have mentioned take part in the planning process, and that this planning process become total and continuous rather than segmental and sporadic, that it be oriented in its strategy to the political aspects as well as to the analytical ones, and that it allows for the intricate web of feedback relationships from a decision-making structure which is becoming even more complex.²³

Two other papers presented at the Fifteenth International Hospital Congress in Chicago in 1967 discuss the importance of the proper approach in planning a medical-teaching center.²⁴ The planning process itself is most critical to the success of the effort. One of the most serious problems is the lack of valid data regarding space requirements and operational needs. Both papers imply a strong need for research and study regarding the planning process.

In discussing organizational arrangements for planning in an

²³*Ibid.*, p. 631.

²⁴Blanpain, J., "Teaching and Research Requirements in a Health Teaching Complex," Fifteenth International Hospital Congress, Chicago, 1967, 9 pp.; Sahl, R. J., "Analysis of the Space Requirements in Health Teaching Centres," Fifteenth International Hospital Congress, Chicago, 1967, 9 pp.

urban teaching medical center, Field²⁵ alludes to the need for the systems approach. He emphasizes the importance of multidisciplinary representation on the planning team, and indicated the role of each type of staff member. The process is described in terms of objectives, information development, measurements, decision points, and feedback mechanisms. Although this publication reflects what is possibly the most advanced work to date regarding the planning process, it does not indicate the incorporation of the techniques of management science.

The significance and the complexity of the problem of planning and designing clinical facilities for medical education has been increasingly recognized in recent years. Also, the possibility of using the analytical and quantitative techniques of management science in this process has become an interesting and promising subject for many people involved in this field. A few studies have been reported. An extensive planning model is being developed at the University of Toronto which will compute faculty and patient resources required for alternative numbers of medical students and alternative curricula designs.²⁶ The TRW Systems Group employed the systems analysis approach in evaluating alternative site plans for the Health Sciences Centre of the University of

²⁵Field, Hermann H., "Organizing the Planning Process," "Medical Schools and Teaching Hospitals: Curriculum Programming and Planning," *Annals of the New York Academy of Science*, Vol. 128, Article 2, Sept. 27, 1965, pp. 670-678.

²⁶The completed work of Richard Wilson and J. R. Walter of The Health Sciences Functional Planning Unit at the University of Toronto has not yet been published.

Alberta.²⁷ A planning group of the Stanford University School of Medicine used operations research techniques in studying the design of obstetrical facilities.²⁸ These studies barely scratch the surface of the entire process of planning for clinical facilities for medical education.

In general, the results of this literature survey indicate the need for a general investigation of the applicability of management science principles and techniques in planning clinical facilities for medical education.

²⁷Rosenbloom, Arnold, Ph.D., "Systems Applications to Health Care Delivery Systems," *The Recognition of Systems in Health Services*, Proceedings of the Symposium on Health, Health Applications Section, Operations Research Society of America, May 14-16, 1969, Washington, D.C., pp. 277-291.

²⁸Wolfe, Harry B., Ph.D., Magdi Iskander, and Tom Raffin, "A Study of Obstetrical Facilities," *The Recognition of Systems in Health Services*, Proceedings of the Symposium on Health, Health Applications Section, Operations Research Society of America, May 14-16, 1969, Washington, D.C., pp. 367-392.

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CHAPTER III

AN EXAMINATION OF THE PROCESS OF PLANNING IN OTHER FIELDS

One of the premises of this investigation is that facility plans should be based upon relatively comprehensive and well-developed managerial and educational program plans. This position seems entirely defensible since clinical facilities are expensive and relatively inflexible as to their function. They are designed to perform specific functions which are directly related to managerial and educational objectives and programs; therefore, managerial and educational program plans form the basis upon which facility plans should be developed.

This investigation is directed toward the potential application of management science principles and techniques in the planning process, i.e., the dynamic process of making the important management decisions related directly to facilities' planning such as general types and quantities of facilities, time schedules, operational and organizational characteristics, and matters of economy. Although these decisions are only part of the process of managerial (or institutional) planning, they are very much dependent upon and interwoven with the entire managerial planning process. Even when no formal or recognizable managerial plan or planning scheme exists, large facilities planning projects raise many long-range and critical questions regarding objectives, programs, organization, methods and other aspects of management

which must be answered in some manner in order for facilities planning to proceed. The issue, then, is how these questions will be answered--by guesses and assumptions on the part of facility planners, or by direct and systematic consideration among the managers of the institution. The position taken in this investigation is that the latter method is the only rational one.

This being the case, the application of management science to the facility decisions mentioned above involves the translation of managerial objectives and plans into "optimal" facility solutions. In order to be effective in this process and to evaluate the applicability of management science principles and techniques, the management scientist needs a comprehensive understanding of the managerial environment, managerial methods, and the nature of the planning process.

In the absence of adequate literature regarding the particular planning process being studied, this chapter undertakes an examination of the planning process in other fields as described in the literature in order to identify principles which could be relevant and applicable to this investigation.

What is Planning, and Why Is it Needed

One common listing of the functions of management consists of planning, operation, and control. In any such listing found in management literature, planning is always included as a primary function of management.

A dictionary definition of planning is as follows: "To form a

scheme or method for doing, achieving, etc."¹ The present purpose is to investigate the process of planning within an organization, consisting of conscious and purposeful decision making and action, and involving futurity. Hence, a better definition of planning is given by the following quotation: "Planning is thus an intellectual process, the conscious determination of courses of action, the basing of decisions on purpose, facts, and considered estimates."²

Planning involves the setting of goals and objectives, the identification and development of alternative courses of action, and, at the appropriate time, the selection of one of the alternatives. It provides guidance for necessary and desirable change. It is the conscious and purposeful act of attempting to link present actions with desired future results.

Formal planning is a relatively new management tool in the United States.³ In the early states of industrial development in this country, planning, at least on a large scale, was somewhat contrary to the temperament of the time, i.e., hearty individualism and a spirit of

¹ *Standard Dictionary of the English Language*, International Edition, Funk and Wagnalls Company, 1963.

² Ewing, David W. (ed.), *Long-Range Planning for Management*, Harper and Row, New York, 1964, p. 22.

³ See Warren, E. Kirby, *Proceedings of the Seventh Annual Symposium on Planning*, College on Planning, The Institute of Management Sciences, May 1964; Ansoff, H. Igor and Richard C. Brandenburg, "A Program of Research in Business Planning," *Management Science*, Vol. 13, No. 6, February 1967, pp. B219-B239; Ewing, David W., "Corporate Planning at a Crossroads," *Harvard Business Review*, Vol. 45, No. 4, July-August 1967, pp. 77-86; Galbraith, John Kenneth, *The New Industrial State*, Houghton Mifflin Company, Boston, 1967, 427 pp.

adventure. This began to change somewhat with expanding technology and increasing capital requirements. Also, the New Deal introduced a form of governmental planning on a national scale. But with the advent of the "cold war" planning acquired certain ideological overtones.⁴ Two primary characteristics of the communist countries were socialized property and *planned* economies; therefore, both socialization and planning were held as suspect in this country. Governmental planning was considered as circumscribing liberty by limiting the exercise of choice by individuals. The people preferred to accept results of the unhampered operation of the free market rather than risk what they viewed as the evil effects of planning.

Until recent years, planning continued to be held highly suspect even by business managers and was associated with the New Deal, impractical intellectuals, and "creeping socialism." The extent of change in this attitude and the increasing use of planning during recent years are indicated by a survey of the chemical industry; as recently as 1948 almost none of the chemical companies in this country engaged in long-range planning, whereas in 1960 90 per cent did so.⁵ The widespread use of formal planning by most segments of our economy today is indicated by publications in management literature and by special

⁴Galbraith, John Kenneth, *The New Industrial State*, Houghton Mifflin Company, Boston, 1967, 427 pp.

⁵Ansoff, H. Igor and Brandenburg, Richard C., "A Program of Research in Business Planning," *Management Science*, Vol. 13, No. 6, February 1967, pp. B219-B239.

publications such as those of the College on Planning of the Institute of Management Sciences.

The increasing need for formal planning has been discussed by two leading authors in management and economics, John Kenneth Galbraith and Peter F. Drucker.⁶ Rapidly advancing technology is one of the primary factors contributing to the increasing need. With the advancing technology comes the lengthening time span of many managerial decisions, i.e., the time between the initiation and the completion of the task resulting from a decision, and the time span of continuing effects of a decision. The application of today's advanced technology in new ways involving new products, ventures, or directions requires relatively long lead times in development.

With the extended times between the initiation and the completion of tasks, and with the consequent lag times of return on investments, more capital is required. The need for capital is further increased by the fact that the special tools, equipment, and plants required for advanced technology are usually more expensive. Also, with increasing technology, the large amounts of money and time are more inflexibly committed to the particular task decided upon. Tasks must be divided and subdivided so that special areas of knowledge can be applied. This division and specialization results in many of the productive resources and systems being designed for particular tasks, with a high degree of functional inflexibility.

⁶Galbraith, *op. cit.*, and Drucker, Peter F., "Long-Range Planning--Challenge to Management Science," *Management Science*, Vol. 5, No. 3, April 1959, pp. 238-249.

The large commitments of time and money and the high degree of inflexibility bring a higher level of uncertainty and risk into the decision process. The decision maker must look further into the future and make systematic efforts to evaluate the pending decision in the light of these uncertainties and risks. Also required are more specialized manpower and more complicated organizations, both contributing to a more complex economy and society. Within such an environment it is not as easy for a manager to make good decisions without paying specific attention to their futurity, and without devoting significant effort to determining possible courses of action, evaluating them, and selecting what appears to be the best course. Thus, the increasing need for formal planning arises.

An example of the effects of increasing technology may be seen by comparing the production of the first Ford automobile in this country with the production and introduction of Ford's Mustang.⁷ The first Ford car was produced in October, 1903, approximately four months after the company was formed; the Mustang was three and one-half years in preparation. The total authorized capital for the Ford Motor Company initially was \$150,000; the cost of engineering, "styling," and tooling-up for production of the Mustang was approximately \$59,000,000. The first Ford engines were made in an ordinary shop that was also used to make bicycles and steam engines; the production line for the Mustang is specialized with very little flexibility. With the first Fords the production time was short enough and the technology simple enough that the managers

⁷Galbraith, *op. cit.*, pp. 11-17.

could depend on reacting to problems as they arose rather than making special efforts to anticipate them; the same approach for the Mustang would probably have led to total failure.

Another factor contributing to the increasing emphasis on planning is the development of the "science" of management, i.e., the application of the approaches and principles of science and engineering in the improvement of the managerial function. When the various sub-functions and decision processes of management are analyzed from a management science point of view, certain conditions having implications for planning are apparent. One such condition is that planning is essential to effective managerial control. How can a manager determine whether things are proceeding in the right direction if a desired future course of action has not been selected?⁸ Another condition is that uncertainty and change are inherent in the economy and in the managerial process. This implies the need to recognize the implications of present decisions for the future, and to evaluate these decisions in the light of the uncertainties and possible changes of the future. Finally, the basic assumption of management science is that decisions can be improved by the conscious and systematic assessment of managerial problems. This is also a basic assumption of planning.

The purpose of planning is not just to produce written reports, programs, and plans. There have been many cases in which the written reports and programs resulting from formal planning have had little or

⁸Ewing, David W. (ed.), *Long-Range Planning for Management*, Harper and Row, New York, 1964, p. 34.

no impact on operations.⁹ The problems with which planning is concerned are continuous; a static plan or a comprehensive written program will not suffice. Any specific plan is necessarily a description of only a few of the many variables involved in the action.

The purpose of planning is to influence decisions and actions. Therefore, planning must be people oriented. It has been said that the "Modification of a planning process has more fundamental and lasting influence on the organization than does direct modification of its output."¹⁰ Thus, the planning process is more important than specific plans. The present chapter concentrates on a descriptive study of the process.

Types of Planning

Planning has several dimensions, variations of which produce the different types of planning. These dimensions include purpose, time, scope, approach, methodology, and type of plan to be developed. Some of the major types of planning will be discussed in the paragraphs to follow.

Planning may be classified as to its purpose, i.e., operational or strategic. *Operational planning* has as its purpose the development of specific operational methods and approaches for accomplishing a given objective. It does not involve the setting or changing of organizational goals or objectives. This type of planning usually assumes a definite

⁹Ewing, David W., "Corporate Planning at a Crossroads," p. 79.

¹⁰Emery, James C., "The Planning Process and Its Formalization in Computer Models," *Information Systems Sciences*, p. 372.

future, and is directed toward the accomplishment of a specified sub-objective which is relatively definite and specific. Activity under this classification may range anywhere from the normal day-to-day planning which everyone must do, and which is not normally called planning, up to the development of a detailed scheme, including methods, staffing, equipment, procedures, etc. for accomplishing some specific function. Various types of functional and technical specialists usually play the major roles in these activities. Examples of operational planning include production planning, developing the schedule and details of moving a plant, and the layout of specific areas in facilities planning and design.

Strategic planning is for the purposes of setting goals and objectives, anticipating the future and its implications for the organization, and selecting the general means of accomplishing these goals and objectives, under anticipated conditions. This type of planning demands an intimate knowledge and understanding of the organization, the industry in which it operates, its resources, its capabilities, and its limitations. It also requires leadership ability to select new objectives and to mobilize the organization to move in new directions, which strategic planning always implies. Intuition, judgment, and broad managerial experience are invaluable. Strategic planning involves the simultaneous evaluation of many variables, most of which are not measurable, with partial information and under conditions of either risk or uncertainty. It is primarily an intellectual process. It does not have a scientific basis, although the methods of science and engineering may be helpful in certain phases.

Along the time scale planning may be classified as short-range or long-range. *Short-range planning* involves decisions which are to be implemented in the near future and for which the anticipated results are not necessarily long-lasting; the decisions could be altered without major costs or serious effects on the organization. It does not usually involve setting or changing organizational goals and objectives, and consequently tends to be operational in nature. Usually, only a few factors are considered variable, while all others are assumed to be fixed; therefore, short-range planning involves a high degree of sub-optimization. In most cases, the planning horizon is on the order of one year.¹¹

Long-range planning involves a planning horizon of many years. Fewer factors are considered fixed, and a lesser degree of suboptimization is involved. Because of the long time period confidence in the constancy of goals and objectives is usually in question; thus, long-range planning tends to be strategic in nature. Long-range planning has been defined as follows:

It is the continuous process of making *present entrepreneurial (risk-taking)* decisions systematically and with the best possible knowledge of their futurity, organizing systematically *the efforts* needed to carry out these decisions, and measuring the results of these decisions against the expectations through organized, systematic feed-back.¹²

Three points will be taken from this definition for further discussion: the continuous nature of the process, the risk-taking aspect of

¹¹Moreno, Ignacio Garcia, *Top Management Long-Range Planning*, Vantage Press, New York, 1963, 300 pp.

¹²Drucker, *op. cit.*, p. 240.

decisions, and knowledge of the futurity of present decisions.

Long-range planning is an integral part of the management of the organization. It is continuous in that risk-taking decisions to be evaluated in terms of their futurity are continuously made within the organization. Also, because of the continuously changing nature of organizations and their environments, objectives should be reassessed periodically, and information feedback from the results of previous decisions should be evaluated in order to measure progress toward these goals. The following quotation points out the importance of and the need for long-range planning:

Underlying the whole concept of long-range planning are two simple insights. We need an integrated decision structure for the business as a whole. There are really no isolated decisions on a product, or on markets, or on people. Each major risk-taking decision has impact throughout the whole; and no decision is isolated in time.¹³

Several different durations of time are cited in the literature as being the usual time span of long-range planning. One indicates that the average span of consideration is close to ten years.¹⁴ Another indicates that the time span of long-range planning in most cases covers at least five years and in some cases covers ten or more.¹⁵ It is further pointed out that "detailed quantitative expressions of long-term

¹³ *Ibid.*, 246.

¹⁴ Branch, Melville C., *The Corporate Planning Process*, American Management Association, New York, 1962, p. 105.

¹⁵ Moreno, *op. cit.*, p. 30.

plans are commonly limited to a forecast period of four or five years, so far as business is concerned."¹⁶

The futurity of decisions determines the appropriate planning horizon and not vice versa.¹⁷ It is usually necessary to consider only that span of time reasonably expected to have significant implications for present decisions and for which projections can be made with sufficient clarity and confidence to be meaningful to present planning activity. Both the nature of the organization and the nature of the decision affect the selection of a planning horizon. In some cases the appropriate planning horizon may be determined by the investment required and the projected period of time necessary to recover that investment and the desired return from it.¹⁸

Another dimension of planning is its scope, in terms of organizational levels and the number of elements of the organization's activity to be considered. Not all of the many activities of an organization can or should be the concern of formal planning. An important decision is the selection of those critical activities and variables to be of major concern.¹⁹ "Even in its most detailed form, a plan

¹⁶Perera, John, (A review of Woolwick Economic Papers--Woolwick Polytechnic, London, "Planning as a Tool of Management," by John Brodrick), *The Engineering Economist*, Vol. 11, No. 3, Spring, 1966.

¹⁷Drucker, *op. cit.*, p. 244.

¹⁸Ewing, David W., *Long-Range Planning for Management*, p. 36.

¹⁹Moreno, *op. cit.*, p. 30.

specifies an extremely sparse set of variables out of the infinite set possible."²⁰

In deciding upon the number of elements to be included, the planner should consider the time, cost, and uncertainty limitations of planning. He must try to strike an optimal balance between the costs of improved planning through increasing the scope versus the cost resulting from less complete information and less realistic plans.²¹ In other words, he should apply the principle of diminishing returns. This point is alluded to in the following quotation:

. . . entrepreneurial (planning) decisions must be fundamentally expedient decisions. It is not only impossible to know all the contingent effects of a decision, even for the shortest period ahead. The very attempt to know them would lead to complete paralysis.²²

Although excessive investigation must be avoided, it is more common in planning practice to omit significant elements than to wander too far afield. In the early stages of planning, an extensive listing of possible elements to be considered should be made. From such a listing, a better selection of elements actually to be considered can be made within the restrictions of time, cost, and method.²³

Another measure of the scope of planning is the number of levels of the organization which are directly involved in the planning activity.

²⁰Emery, *op. cit.*, p. 371.

²¹*Ibid.*, p. 385.

²²Drucker, *op. cit.*, p. 246.

²³Branch, *op. cit.*, p. 79.

Planning is hierarchical in nature.²⁴ This is exemplified by the way in which the "global" objectives of the organization must be factored into more tractable subobjectives and perhaps factored again and again until subobjectives appropriate and meaningful to each level of the organization are obtained. Another indication of the hierarchical nature of planning is the sequential flow of decisions from top to bottom in the organization. Planning decisions at top levels become constraints for lower levels. This does not mean that planning is a unidirectional activity; planning decisions made at one level may depend upon information and judgments from lower levels. However, not all levels need be included in all planning decisions. It is important that the planner decide which levels of the organization should be included in specific formal planning activities. The "scope of realistic planning cannot exceed the range of activity or consideration of the entity within which it is formulated, for which it is intended, and by which it is implemented."²⁵

Four other forms of planning have been identified.²⁶ These are developmental, adaptive, allocative, and innovative planning. The

²⁴ Emery, *op. cit.*, p. 374-376.

²⁵ Branch, *op. cit.*, p. 74.

²⁶ Friedman, John, "A Conceptual Model for the Analysis of Planning Behavior," *Administrative Science Quarterly*, Vol. 12, No. 2, September 1967, pp. 225-252. In this article, planning is defined as the "guidance of change within a social system." It deals with forms of planning directed toward change, and not with other forms such as operations research. Also specifically excluded are institutional forms of planning; however, the forms of planning described would seem to be involved in institutional planning also.

characteristic which distinguishes between developmental and adaptive planning is the relative autonomy of planning units in making decisions. A high degree of autonomy in setting ends and choosing means is characteristic of *developmental planning*. Although this type involves a technical function, it is, to a considerable extent, political in nature. This is usually the case in the setting of objectives or desired ends. The relationships between the technical planners (experts) and the policy makers (politicians) are crucial. The role of technical planning may be summarized as follows:

Technical planning, therefore, moves temporarily into the foreground whenever goals are clear, widely held, and deemed to be important; whenever in such a situation system performance is believed to depart significantly from the norm; and whenever, given all these conditions, expert judgement coupled with a variety of control mechanisms is held to be more effective than political manipulation. Where these conditions do not occur, planning is likely to be reduced to a vestigial function only.²⁷

Adaptive planning is characterized by the dependency of planning decisions upon the environment and the action of groups external to the entity for which plans are being developed. Adaptive planning is opportunistic in nature. It tends to be more a form of *programming* than *policy making*, and it tends to elevate decisions upward to levels of the organization where developmental plans are made.

Allocative planning is defined as the process of allocating resources among competing uses. An optimality criterion is the guide for this type of decision. Synthetic models, such as input-output matrices, simulation models, and econometric policy models are often used. The allocative planners accept the goals and priorities furnished

²⁷ *Ibid.*, p. 234.

to them by the policy makers; they do not attempt to make such value judgments themselves. Allocative planners develop means for accomplishing goals, work out their implications, sometimes point out inconsistencies among goals, and usually establish some set of measures of the achievement of goals. Allocative planning is intended to be an objective process.

Innovative planning is concerned with producing major changes in existing social systems. Major change in this context means dramatic and rapid change, not to be obtained by gradual and incremental changes in the present system. Some of its distinguishing characteristics are as follows:

1. Innovating planning seeks to introduce and *legitimize new* social objectives. . . .
2. Innovative planning is also concerned with *translating general value propositions into new institutional arrangements and* concrete action programs. . . .
3. From this it follows that innovative planners are public entrepreneurs who are likely to have more interest in *mobilizing resources* than in their optimal allocation among competing uses. . . .
4. Innovative planners propose to guide the process of change and the consequent adjustments within the system through the feedback of information regarding the actual consequences of innovation, in contrast to allocative planners, whose main endeavor is accurately to predict the chain of consequences resulting from incremental policies and then to adapt these policies to the prospective changes.²⁸

Innovative planning is especially prevalent in situations where rapid change is being attempted or is actually taking place. It is a method of coping with problems where progress on all fronts at once is not possible, where specific ends are not fixed although general ends may be

²⁸*Ibid.*, pp. 244-246.

stable, and where change is so rapid that guidance through the use of target achievement is not possible.

Another method of classification is by the types of plans to be produced. Some of the major types of plans relate to objectives, policies, procedures, budgets, and programs.²⁹ Objectives form the targets of the organization, i.e., the ends toward which it strives. *Policies* are general statements or understandings which guide, support, or constrain the actions and decisions of members of the organization; they are standard solutions or patterns for certain decision and problem situations which occur repetitively. *Procedures* involve a detailed chronological sequence of steps indicating the manner in which a certain activity is to be accomplished. A *budget* is a plan for the allocation of resources stated in numerical terms and linked to expected results. It may indicate the allocation in terms of money, man-hours, units of production, etc. A *program* is a combination of all of the above types of plans. It is designed to achieve a set of objectives within certain policy guidelines following a particular course of action, and it indicates the allocation of resources required for the task to be undertaken. The development of each of these types of plans requires various types of planning.

Each of the above types of planning are likely to be involved in any large facilities planning project. The relative importance of the various types in any particular project is a primary factor in determining other characteristics of the planning process. Some of the other

²⁹Ewing, David W., *Long-Range Planning for Management*, pp. 23-28.

characteristics will be discussed in the following sections of this chapter.

The Nature of the Planning Process

In the remainder of this chapter, except where otherwise stated, discussion will be limited to the institutional (or corporate managerial) planning process. The purpose is to analyze, through selected literature, the types of planning in corporations and other institutions which seem to be closely related to the types involved in planning programs and facilities for clinical education in a health education institution.

As indicated earlier, planning is one of the primary functions of management. Institutional planning is basically a managerial process involving the setting of goals and objectives for the future and the development of means for achieving them. All managers make decisions which have a direct bearing on the performance of their organization in the future; therefore they all are involved in planning. The issue is whether or not they make these planning decisions systematically and with full consideration of their implications for the future.

Long-range planning is the responsibility of the top executives of the organization. This does not mean that they develop all of the plans and their details. Some of the planning activity will be performed by lower level managers, and there even may be a planning staff. The planning process, however, requires the support of top management, and the top executive must bear the responsibility for the final decisions and their consequences.

The basic purpose of planning is to influence decisions and action so that objectives are achieved in the future. If this does not happen then planning has failed, no matter how sophisticated or impressive a plan may have been developed.

It is reported that corporate records contain many cases of written plans or programs which had little or no impact on operations and performance.³⁰ In order to accomplish its purpose planning must be "people oriented." There must be a tie-in between planned programs and present operations, between procedures and people, and between planned goals and the proven abilities and desires of the human organization.³¹ These points indicate the weaknesses of those forms of planning which emphasize only the predictive-economic aspects of the process.

Formal analysis is only one of the ways in which planning can improve the future performance of an organization. Significant successes have been achieved by "planning-minded" groups with other approaches.

One approach, for instance, is the development of consensus on desirable corporate goals. Another is the development of increased awareness of the need to use common assumptions about the future, so that one group or division does not take actions that undermine the actions of another.³²

The "developmental" approach emphasizes the action and people aspects of planning.³³ Based upon the principle that goals should be

³⁰Ewing, David W., "Corporate Planning at a Crossroads," p. 79.

³¹*Ibid.*, p. 86.

³²*Ibid.*, p. 79.

³³Schaffer, Robert H., "Putting Action Into Planning," *Harvard Business Review*, November-December, 1967, pp. 158-160, 163-166.

commensurate with managerial capability, the first planning projects should involve goals which are short-ranged so that within a relatively short time managers can gain experience and confidence from successfully completing projects. The scope of planning project goals may then be expanded in relation to the growth in management's ability to handle them.

Some authors contend that major planning efforts should not be undertaken unless or until major current problems are solved.³⁴ It seems that this position may be contradicted by some of the behavioral viewpoints; for example, consider the purpose and approach of *innovative planning*. Most experts would probably agree, however, that planning must be pragmatic. The usefulness of plans can be judged only in respect to the people and the decisions they are intended to guide.³⁵

Formal planning is still a relatively new process in most institutions. Although a significant amount of work has been done in this field in recent years, and although there is general agreement on the major steps of the process,

Much remains to be accomplished, however, in the development of a methodology of corporate planning. As yet, there are few established procedures and techniques.³⁶

Institutional planning requires the participation of many disciplines and the integration of the knowledge, principles, and approaches

³⁴Ewing, David W., *Long-Range Planning for Management*; See "Steps in Long-Range Planning," p. 232, by Bruce Payne.

³⁵*Ibid.*, p. 360.

³⁶Branch, *op. cit.*, p. 33.

of many fields. The methodology and approach of no one discipline are adequate to the total job of planning. While the trend in our society is toward an increasing subdivision of knowledge and professional specialization, planning requires an integrative knowledge and approach.

A recent article entitled "A Program of Research in Business Planning" listed a number of unanswered questions which indicate the present state of the art and science of planning, as follows:

How much planning is enough; what are the cost-benefit relationships in planning; what kinds of planning are appropriate to different firms, to different business conditions within firms; how should firms organize for planning; how should planning practices differ among industries; how should uncertainty be handled?³⁷

Although planning presupposes the use of reason, many decisions require a high degree of intuition and judgment because of lack of time or resources for thorough study, incomplete information, and the inappropriateness of analytical and quantitative methods. Many aspects of the process involve matters of human behavior and value judgments. An understanding of the general nature of mental-emotional processes is essential in applying reason.³⁸

Certain types of planning demand an extensive application of creativity and imagination. This is especially true in setting new directions for the organization and determining new means of achieving objectives. It has been claimed that much of current planning activity is deficient in this respect:

³⁷Ansoff and Brandenburg, *op. cit.*, p. B-219.

³⁸Branch, *op. cit.*, p. 89.

. . . planning has tended to become a mere administrative process of endless criteria, and the creative quality of the alternatives examined is scarcely worthy of the sterile perfection of the decision system applied. As a result, imaginative ideas entailing some real element of uncertainty tend to be cast aside in preference for safe trivia. Yet, as we have seen, the profit rewards from endlessly doing old things more efficiently also are trivial.³⁹

The decisions made in long-range and strategic planning affect all elements and activities of the organization. The explicit and direct evaluation of all relevant elements and activities is usually impossible; therefore, an important aspect of planning is the selection of those critical factors which will receive direct and concentrated consideration.

Another important aspect of the institutional planning process is the handling of uncertainty. It should not be assumed that planning eliminates or minimizes uncertainty and risk. It does not. Hopefully it will lead decision makers to take the right risks through recognition of the nature of the risk involved in each alternative.

History has shown that one cannot depend upon forecasting the future. One can only anticipate the possible futures and attempt to develop decisions, directions, and activities which will result in taking the right risks and being prepared for change as necessary.

But there is another, and even more compelling reason why forecasting is not long-range planning. Forecasting attempts to find the most probable course of events, or at best, a range of probabilities. But the entrepreneurial problem is the unique event that will change the possibilities, for the entrepreneurial universe is not a physical but a value-universe. Indeed the central entrepreneurial contribution and the one which alone is

³⁹Ewing, David W., *Long-Range Planning for Management*, See "Focus on Profit Opportunities, Not Efficiencies," by John B. McKitterick, p. 75.

rewarded with a profit, is to bring about the unique event, the innovation that changes the probabilities.⁴⁰

The degree of uncertainty apparent in decisions will vary with the various levels of the organization. One reason for this is that assumptions are made regarding a point of uncertainty at one level of the organization and passed down to the next level as stipulated conditions. This is called *uncertainty absorption*. It is one way of achieving a certain degree of direction and consistency in the planning process.⁴¹

There are several methods of handling uncertainty and risk in decision processes. One of the most common methods is *sensitivity analysis*, which involves an investigation of the degree of change in outcomes resulting from alternative values of variables which are subject to uncertainty. Other methods will be discussed in subsequent chapters.

Steps in Planning

The following list of general steps in planning is representative of most such outlines in the literature:

- (1) Setting goals and objectives.
- (2) Making assumptions and establishing premises.
- (3) Developing alternative means for achieving goals and objectives.
- (4) Making "forecasts" (anticipating possible futures), and projecting results.

⁴⁰Drucker, *op. cit.*, p. 239.

⁴¹Emery, *op. cit.*, p. 376.

- (5) Deciding among alternative means.
- (6) Implementation.
- (7) Evaluation and feedback.

Each of these steps will be discussed briefly in the following paragraphs.

The terms "goals" and "objectives" are often used synonymously; however, in some cases one term is used to indicate a higher order than the other. In general these terms refer to the ends which the institution is trying to achieve; in other words, they indicate what the institution is trying to become. Setting objectives is the first and one of the most critical elements of planning. Objectives determine the direction of all other efforts.

Top-level objectives state what the institution expects to achieve with respect to its environment and to society. Statements of these objectives are generally very abstract. They must reflect the needs of the various groups essential to the continued existence of the institution. Institutional level objectives should be factored into subordinate objectives for each relevant organizational unit. The resultant hierarchy of objectives should be consistent and easily understood so that it provides a framework for decisions and operations within the institution. Lower level objectives are more specific and concrete. They should be realistic and attainable.⁴²

⁴²Ewing, David W., *Long-Range Planning for Management*; See "Steps in Long-Range Planning," by Bruce Payne, p. 223.

There are at least three different ways in which objectives may originate:

- (1) by "enunciation," i.e., by management's carefully assessing the organization's future purposes and communicating these in an organized system;
- (2) by "appeal," i.e., by subordinate groups submitting proposals to management until its pattern of decisions indicates that an organizational objective exists (even though not formally enunciated);
- (3) by "external imposition," i.e., through outside pressures such as those of the government, labor unions, or the international situation, forcing the organization in certain directions.⁴³

Usually objectives originate in an organization by all three of these methods.

In addition to providing a basic framework for planning, the development and statement of objectives offers other benefits. This process brings objectives into the consciousness of management. It helps bring to light differences in approach or aims and leads toward consistency of plans among the various units within the institution. It also provides standards against which performance can be measured.⁴⁴

Regardless of these reported benefits, very few managers have well-defined overall objectives to guide their operations.⁴⁵ Compounding this situation is the fact that many managers have personal objectives which influence the actions of the institution. These personal objectives may not be entirely consistent with the institution's

⁴³Ewing, David W., *Long-Range Planning for Management*; See "Top-Management Guides for Research Planning," p. 365.

⁴⁴Perera, *op. cit.*, pp. 40-41.

⁴⁵Moreno, *op. cit.*, p. 21.

objectives. For example, "The motivation of management security is probably more widespread in business and more of an objective of planning than is generally realized."⁴⁶ These conditions must, of course, be overcome in order to develop a well-founded long-range facilities plan.

It has been said that the real problem is not in determining objectives but rather is in setting them so that management knows what variables indicate progress and how to measure them.⁴⁷ Measurable variables which will indicate progress relative to objectives should be identified. Without measurement, it is difficult to plan, and feedback and control are impossible. These variables must be selected with care, since what is measured and how it is measured tend to determine what is considered to be relevant.⁴⁸

Assumptions represent what the decision makers believe to be true about the institution's internal and external environment, or what they are willing to take as true for a particular purpose or a particular line of investigation. Since all aspects of the internal and external environment cannot be investigated and proven, assumptions are a necessary and important part of the planning process. They are the second major element of the setting or milieu in which planning

⁴⁶Ewing, David W., *Long-Range Planning for Management*; See "The Nature and Purpose of Planning," by Harold Koontz and Cyril O'Donnell, p. 25.

⁴⁷Moreno, *op. cit.*, p. 22 (From Peter F. Drucker, "The Practice of Management," Harper and Brothers Publisher, 1945, pp. 63-65).

⁴⁸Drucker, *op. cit.*, p. 247.

takes place. If poor and inaccurate assumptions are made, then planning will be based on a shaky foundation. The making of good assumptions demands a great deal of knowledge and understanding relevant to the particular institution involved, its industry, and its environment.

The top managers of the institution should select the assumptions for planning. A common basis throughout the institution is needed for good planning, even if this basis consists of several different sets of assumptions for which different sets of plans are to be developed. Without a common basis the plans of the various organizational units will not likely be consistent and may even undermine each other.

The next step is the identification and description of alternative courses of action for achieving the objectives. This involves the specification of programs, resources, methods, etc. This step may require an extensive search for ideas, concepts, methods, technology, available resources, and other types of information from which to develop alternative means. Creativity, imagination, and innovation are invaluable qualities in this phase of the process. The success of the institution in achieving its objectives will be limited to the best of the alternative means considered.

After the determination of alternative means, possible states of the future must be anticipated, and the results of the various alternative means under each anticipated state must be projected. Although this may involve some "forecasting" in the usual sense of this word, in most cases, planning should not depend upon forecasting.

"Anticipation" of possible futures is a better approach.⁴⁹ This "look into the future" provides the third element of the framework for evaluating alternative courses of action. It also brings to conscious attention the possibilities of the future in time to allow for necessary adjustments in decisions and operations.

Because of the inaccuracies of long-term forecasts, one of the primary functions of planning should be to provide the flexibility to meet the requirements of the inevitable and unpredictable changes. The degree of justifiable confidence in forecasts and predictions is also one of the major factors in selecting the optimal planning horizon. With a shorter planning horizon and decision time span, more relevant and reliable information is usually available, and there are likely to be fewer changes of decisions and commitments. Considerations such as those indicate that the timing of a decision is a critical decision in and of itself.

Estimates of the future may in some cases be based upon forecasts using mathematical techniques, but they usually must also consist of a considerable amount of judgment and qualitative evaluation. The projection of the expected results of alternative means will usually be more dependent upon analytical and quantitative techniques. In some cases complex and sophisticated models may be used.

After the projection of expected results, a decision must be made among the various alternatives. The decision should be based upon a

⁴⁹The usual meaning of "forecasting" is taken to be the projection, by mathematical or other means, of present and past trends into the future.

comparison of the expected results of the alternatives measured against the criteria derived from the institution's objectives. Usually this comparison will call for some technical analysis and will offer opportunity for the application of decision-analysis models. However, since many planning decisions will not be amenable to quantitative analysis or measurement, value judgments and "political" action will necessarily be involved. The decision structure established for planning should recognize the necessity for the value judgments and "politics." The ultimate responsibility for selecting the course of action must rest with top management in order for the planning effort to be successful.

Following the decision is the implementation of the course of action chosen. This is the pay-off of the entire planning process. In this phase it is decided who is to do what, and when and how they are to do it. Line management carries the responsibility for implementation; staff specialists are usually involved only to the extent necessary to make adjustments to plans and to assist in evaluation.

Finally there is the evaluation of results. Evaluation is a comparison between "results" obtained and "desirable" results, as against valid criteria, i.e., a comparison of objectives and results. Here the importance of measurement is exemplified. Without measurement there can be little or no evaluation. Evaluation and feedback permit managerial control and provide for the continuous updating and revision of plans. This step closes the planning loop and provides the essential dynamic quality of planning.

It should be noted that even though the various phases of planning as described above appear to be sequential, the actual process of planning will not follow such a neat order. There will be feedback loops and recycling through all of the steps of planning; during the planning process, activities in many of the steps may be taking place simultaneously. Planning is a continuous process of change, updating, and recycling.

Management of the Planning Process

Although almost all sections of this chapter relate to the management of the planning process the present section brings together and summarizes some of the key points, with emphasis on information development and communication which provide the "drive" for planning.

While planning pervades all of management, the ultimate responsibility for institutional long-range or strategic planning rests with the chief executive. Without his interest and support these planning efforts will almost surely fail.

Various planning responsibilities and activities should extend throughout the management structure. Planning is hierarchical in nature, and should involve a complete network of objectives, responsibilities, and activities for each organizational unit. The sequencing of decisions and activities through this network is a critical aspect of managing the process; higher level organizational units may require planning information from lower levels, while the plans developed at higher levels impose constraints on planning at lower levels.

Since all elements of an institution's activities cannot usually be explicitly considered in any one planning project, the selection of the critical elements which will be considered is required. This is usually best done by starting with a broad listing of elements and trimming it down as required by time and resource constraints as the planning progresses.

Another aspect of the scope of the planning activity is the number of levels of the organization to be directly involved. This will depend upon the type of planning and the particular decisions involved. In deciding upon both the number of activities and the number of organizational levels to be included, the planner should evaluate the "cost" of time and other resources expected to be expended in planning and attempt to balance them against the possible gains.

Several important aspects of managing the planning process relate to information development. Information is the fuel for planning. The planning process itself consists largely of information development, communication, and decision making. The information gathering processes in institutional planning will usually be extensive and complex. In order to help assure proper use, the accuracy, limitations, identity of source, interpretations, and assumptions relative to the information gathered should be clearly indicated and recorded. Also, these factors should be appraised periodically to assure that the information used in planning remains current.

All planning information should be developed for a purpose. The information should be kept as simple as possible and stated in

consistent terms so that it is comparable throughout the institution. Care should be taken that no essential or valuable information is lost by arithmetic manipulation or other transformation.⁵⁰

In most cases it is either impractical or impossible to obtain complete and precise information. A frequent mistake is the consumption of too much time and resources attempting to obtain complete information of precise accuracy, with the result that certain opportunities for productive action are lost.⁵¹

The data and information readily available within institutions will usually have many deficiencies with regard to their usefulness in planning. First of all, planning requires information on possible future operations, whereas the information normally available is historical. Often only averages are available, whereas incremental values may be needed. Accounting systems furnish actual expenditures, or actual costs at best, whereas opportunity cost estimates will probably be needed. The data which are available may require complex transformation and interpretation before they can be used for planning purposes. In too many cases it is necessary to rely on the subtle and sophisticated judgment of the manager because of the lack of adequate data.

With the deluge of information (both good and bad) available and confronting the decision makers, and with the large amount of additional information needed for detailed planning, the task of information

⁵⁰Branch, *op. cit.*, p. 83.

⁵¹*Ibid.*, p. 81.

handling and evaluation is practically impossible without a systematic approach. In fact, most of the mechanics of the planning process consist of information development, processing, and dissemination. Systematic organization and presentation of information are very important, often more important than information analysis. The systematic organization of information allows more effective use of intuition, insight, hunches, and judgment, all of which are vital in most types of planning.

The planner is constrained by his perceived states of the institution and its environment rather than by their "true" states. If adequate information is not obtained the planner will be operating with an unsuitable analogue of the "true" states.⁵²

Communication is another important aspect of managing the planning process. Communication is what makes the planning process operate. Through effective communication the involvement and participation of all necessary elements of the organization are obtained. Good communication is essential to achieve the consistency and direction required for success of the planning effort. It provides the information required for planning at all levels of the organization, and helps avoid duplication of effort. It furnishes feedback to top management, indicating the progress and success of the planning process and needed adjustments. As a byproduct, the planning process itself usually improves general managerial communication within the institution.

In order to manage the planning process effectively, the enforced

⁵²Emery, *op. cit.*, p. 376.

discipline of a time schedule is needed. Unless the senior planners set dates for the accomplishment of particular projects the jobs probably won't get done. One reason for this is that planning usually lacks the built-in pressure for timely accomplishment which is inherent in the operational environment. Without the discipline of a time schedule, line managers who are supposed to be involved in planning will probably devote their time and resources to more pressing operational problems, and staff planners will tend to work on those things which are of most interest to them, regardless of their urgency to the planning process.

The time schedule, while being firm enough to provide a discipline, should also be flexible enough to respond to the changes inherent in the planning process. The timing of steps in the process will usually change much more often than the steps themselves change. It may be advisable to develop alternative time schedules contingent upon the occurrence of certain events.

These few critical aspects of managing the planning process obviously do not form a complete concept. They must be combined with considerations in other sections of this chapter, such as those of the following section on approaches and methods.

Approaches and Methods

There are various approaches and methods which may be employed for a given planning effort. A few considerations related to choices among them will be discussed in this section.

In any large-scale planning effort there are numerous elements which must be considered. Many of these elements will be interdependent,

and many will involve time (or precedence) relationships. One of the primary decisions in developing an approach to planning is which of the elements are to be developed simultaneously (or in parallel) and which are to be developed sequentially. Because of the difficulty of handling numerous elements at once, there may be a tendency to handle most of them sequentially. However, because of the interaction and interdependence of many of the elements, parallel development may be necessary. Parallel development should help achieve better integration and greater efficiency in the planning process. Parallel development is usually recommended, even though it requires more extensive coordination and control.⁵³

A combination of parallel and sequential development of the various planning elements can provide the feedback and interconnections required for an efficient and dynamic process. The planning activity network may be analogous to the operation of an electrical circuit, where some components are in series and others are in parallel, and where feedback loops intermesh the circuit so that its operation is not a simple sequential process. The feedback and interaction among components are essential aspects of the dynamics of the process.

Another apparent dichotomy in the selection of a planning approach is the outside-in vs. the inside-out approach.⁵⁴ With the outside-in approach an institution would determine its strategy based upon forecasts and a study of the market within which it operates.

⁵³Branch, *op. cit.*, p. 78

⁵⁴Ewing, David, W., "Corporate Planning at a Crossroads," pp. 83-85.

The opportunities, challenges and demands of the market are weighed against the strength and resources of the institution. Under this approach, primary emphasis is on the market forecast.

There are at least two sources of difficulty with the outside-in approach. First, long-range market forecasts are notoriously inaccurate. Among the many reasons for erroneous forecasts are changes in the economy and advances in technology. Second, from a competitive point of view, this approach is not enough, even with reliable forecasting. Competitor institutions are usually employing this same type of planning, so any relative advantage is lost. Studies of the market have become a necessity for competitive institutions rather than a means of gaining relative advantage.

With the inside-out approach, the decision objective in planning is the exploitation of the institution's strength and resources. Market forecasts and managerial judgment are used as a check or constraint on strategies developed on the basis of strengths and resources. Important assumptions in this approach are as follows:

- (1) Without concentrating on strengths, the institution will probably turn out to be "average," which may be inadequate.
- (2) An institution can create markets through its actions and innovations.
- (3) Market forecasts and judgments should be imposed as checks and constraints.
- (4) The institution's special strengths and resources are more lasting than its particular products.

It seems that the selection of a planning approach need not be a dichotomous choice between these two types; planning for some elements of the institution might be based upon one of these approaches, while that for other elements is based upon the second approach. The appropriate mixture of these approaches will depend upon the type of institution, the type of planning being undertaken, and the circumstances of the time. Also, the question of competitive advantage may not be relevant for "not-for-profit" institutions.

It is important that the uncertainty inherent in decisions regarding the future be specifically recognized in the planning process. In the normal course of planning, uncertainty is "absorbed" at various levels of the organization through assumptions and judgments which are handed down to lower levels as "facts" or certainties.⁵⁵ The matter of who will deal with the various elements of uncertainty should be explicitly considered when developing the methods and procedures for planning.

In many cases decision analysis models and other formal planning models are helpful to the planner as methods for dealing with uncertainty. These usually demonstrate the sensitivity of the decision to the elements of uncertainty involved.

Measurement is very difficult and yet very important in the methodology of planning. It is difficult because planning involves the future, which is not measurable in the present; because many intangible factors are involved; and because complex multi-dimensional situations

⁵⁵Emery, *op. cit.*, p. 376.

are involved. Measurement is important in order to indicate progress toward objectives and to place elements in proper relative proportion and perspective. Measurement also tends to provide insights and to improve judgment and understanding.

In many planning decisions the measures needed are those to be derived from marginal analysis. Marginal costs may be needed in order to determine the optimal investment or level of operation, or to evaluate the profitability of various alternatives. Unfortunately, in most cases the measures readily available are averages or other standard accounting analysis rather than marginal values, and the raw data necessary for marginal analysis is usually very expensive to obtain. The number of significant variables involved in many decisions will make the collection of extensive data and the performance of marginal analyses impossible or prohibitively expensive.

When complex planning problems involve the consideration of numerous elements and various values for variables, more than verbal discussion and internalized mental effort may be required in order to structure and visualize the problems in a manner simple enough to lead to solutions or decisions.⁵⁶ Visual and graphical exposition can help externalize the mental effort required in structuring and analyzing these problems, and can help to identify the important elements, gain insights, and improve judgments. Visual and graphical expositions are therefore important and relatively common aids in formal planning. In many cases, however, there may be a tendency to avoid these techniques

⁵⁶Branch, *op. cit.*, p. 154.

since few people have developed the ability to structure problems in this way.

Many other technical and analytical methods are useful in planning. It should be reemphasized, however, that planning is far from being a science, and scientific and analytical approaches may play minor roles. Decision analysis models are of value in the planning process, but their role is limited by several factors. One of these factors is the number of immeasurables involved in most planning efforts, which reduces the effectiveness of present decision analysis models. Another is the lack of available and adequate information for the use of even those models which would otherwise fit the conceptual structure of the problem. Decision analysis and other approaches included in systems analysis and operations research are useful in furnishing partial answers and in helping to structure a systematic approach to the decision process. These will be discussed further in a section to follow.

Behavioral Aspects of Planning

Opposition among some executives often appears in the early stages of planning.⁵⁷ Many people and organizations find planning activity trying and difficult. By its very nature planning challenges the status quo and raises serious questions simultaneously. Often, it is easier to consider immediate and operational matters which offer the satisfaction of short-range results, than long-range problems which involve an indefinite future, numerous variables with shifting values,

⁵⁷Ewing, David W., "Corporate Planning at a Crossroads," p. 80.

and results which may not be measurable for a long time. Considerable time, exposure, and involvement in planning may be required before personnel within the organization become accustomed to the process.⁵⁸

There are numerous difficulties in introducing formal planning activity into an organization. It is usually recommended that formal planning be introduced slowly, with the planning staff and the managers undertaking rather limited projects at first to develop some experience, skill, and confidence.⁵⁹ Planners should not undertake projects which exceed the administrative and managerial capacity within the organization.⁶⁰

Planning should be people oriented with emphasis on action, rather than on the production of plans and reports by a non-involved staff. To accomplish this, management should support and be involved in the planning activity.

The mixture of political and technical components of planning will vary from one institution to the other and with the types of planning being undertaken. There will, however, always be a high degree of political content in institutional planning.⁶¹

There is usually a strong interdependency between experts and politicians in a planning process; neither can accomplish successful planning without the other. Decisions usually represent a synthesis

⁵⁸Branch, *op. cit.*, p. 46.

⁵⁹Moreno, *op. cit.*, p. 31.

⁶⁰Friedman, *op. cit.*, p. 235.

⁶¹As used here, the term "political" includes the policy making functions.

of expert and political judgments. Exclusion of the politician eliminates the input of political judgment, and often results in plans not being carried out. Exclusion of the technical expert may result in plans not being adequate or appropriate.⁶²

The relative influence of a technical planning function in guiding social and economic change will depend chiefly on five variables; (1) the clarity of system objectives, (2) the extent of consensus about them, (3) the relative importance that politicians attach to them, (4) the degree of variance relative to objectives expected in the performance of the system, and (5) the extent to which a technical (as contrasted with a purely political) approach is believed capable of making system performance conform to these objectives.⁶³

In process-oriented planning the participation of the organizational units or personnel principally interested in the results is sought. "Strong" and "weak" forms of this type of planning are encountered. The strong form involves primarily bargaining with and among the principals. The results represent a synthesis and compromise of objectives and are compulsory to all organizational units involved. In the weaker form there is little negotiation and there may be no formally approved and written plans. Implementation and results are expected to derive from the participation of the principals and through their joint consideration and dialogue on planning issues, which hopefully will lead to a wider awareness of problems, a common information base, common objectives and assumptions, and more responsible decision making.⁶⁴

⁶²Friedman, *op. cit.*, p. 232.

⁶³*Ibid.*, pp. 233-4.

⁶⁴*Ibid.*, pp. 242-3.

The line managers' planning efforts may be supplemented and supported by staff personnel. The background and capabilities of these staff personnel may vary considerably. There are certain important characteristics, however, which the staff should possess because of the nature of planning as a process of change and adjustment. These characteristics are personal adaptability, analytical flexibility, and the capacities to conceptualize and to think in terms of almost continual adjustment. These attributes are natural to some people, while other people find them difficult or even impossible to acquire.⁶⁵

Planning processes often lack the enforced disciplines of time schedules and productivity requirements which are common to operational processes; therefore, both self-starting and self-sustaining interest is required of the planning staff. There are individuals who require, or are better suited for, daily and active involvement in operations and who cannot adjust to the requirements of planning.⁶⁶

Understanding the general nature of mental-emotional processes is essential in determining how human reason is best applied in comprehensive planning: in procedural organization, policy formation, and the selection and utilization of the individuals most directly concerned with the corporate future.⁶⁷

Management Science and Planning

While there is general agreement on the broad steps involved in planning, there are few established and generally acceptable procedures

⁶⁵Branch, *op. cit.*, p. 111.

⁶⁶*Ibid.*, p. 153.

⁶⁷*Ibid.*, p. 89.

and techniques.⁶⁸ Planning cannot be reduced to simple facts, axioms, or principles so that a unified, logical, theoretical structure could be produced. Under these conditions, there are few definite, specific, and objective guidelines for the planning process; most guidelines are general and subjective, and relate to philosophy, basic approach, and working principles. One of the primary methodological objectives of planning, however, is the maximum use of reason in decision making regarding the future, even though reason may not be fully adequate to the task.

Management science and planning have at least one primary characteristic in common. In a world of increasing subdivision of knowledge and specialization in professions, management science and planning are in a category representing a growth of integrative knowledge involving various fields and applications.⁶⁹

The scientific method is employed in few, if any, aspects of the typical institutional planning process. There are several apparent reasons for the limited role of the scientific method. For example, very few scientifically verifiable laws and little scientific knowledge have been developed regarding the various elements of an institution and their combined operation as a system. There are usually numerous factors which are immeasurable and many outcomes or consequences which are incommensurable. Also, human behavior and value judgments are

⁶⁸*Ibid.*, p. 33.

⁶⁹*Ibid.*, p. 34.

critical factors in the planning process. Much research and development is needed in the application of scientific methodologies in improving the planning process.

It is obvious that planning must extend beyond the bounds of present scientific knowledge in order to encompass all significant elements of the institution individually and as a system. Scientific methodology cannot handle individual acts of human will, which are often of critical importance in the course of future events. Much of planning is purposeful human action, and its realm is human events; at the present time these characteristics of institutional planning tend to delimit the role of scientific planning.

It has been said that planners have mistakenly forgotten the philosophers. Intellectual advances are needed in planning as much as scientific discoveries.

. . . it has been observed quite aptly that no program of breeding horses, however scientific, would ever have produced the internal combustion engine. Similarly, we can say that no progress of applying science to human affairs will give us the intellectual advances we need today.⁷⁰

The use of science and the scientific method is placed in perspective in the following quote:

Life cannot wait until the sciences may have explained the universe scientifically. We cannot put off living until we are ready. The most salient characteristic of life is its

⁷⁰Smiddy, Harold F., "Planning, Anticipating and Managing," *Proceedings of the Seventh Annual Symposium on Planning*, College on Planning, The Institute of Management Sciences, May 1964, quoted from "Security is Too Important To Be Left to Computers," *Fortune*, April 1964.

coerciveness; it is always urgent 'here and now' without any possible postponement.⁷¹

Another limitation of the scientific approach in planning is the lack of suitable data. Almost all of the data and information available within an institution is historical, whereas planning involves the future, which may not be an extension of the past. Also, much of the data base of an organization is developed by accounting methodologies which are not structured with planning decisions in mind. Complex transformations may be required to convert the available data into a form of even limited usefulness. Much planning data must come from judgment and policy decision, and therefore is not appropriate for application of the scientific method. These characteristics of available data limit the usefulness of many of the models and approaches of management science.

The design process and the planning process are similar in many respects, e.g., the role of creativity and deductive reasoning. It has been pointed out that design is much different from research.⁷² Research is performed to establish new principles, theories, and knowledge. In the design process, useful products are developed by applying the results of research, technology, creativity, and resources. Engineering and design methodologies are not as well founded as those of research. The hallmark of research methodology is analysis; whereas, analysis has

⁷¹*Ibid.*, quoted from "Mission of the University," by Ortege Y. Gasset.

⁷²Nadler, Gerald, "An Investigation of Design Methodology," *Management Science*, Vol. 13, No. 10, June 1967, pp. B-642-655.

certain shortcomings in the design process, as follows:

(1) Analysis requires that existing phenomena be analyzed; design produces new phenomena or products. Furthermore, the analytical approach may restrict the creative vision necessary for design.

(2) The analytical approach emphasizes components rather than wholeness; design requires wholeness. The analytical approach may lead to suboptimization.

(3) The analytical approach may lead to technique orientation rather than problem orientation.

(4) Emphasis upon the analytical approach may create a communication gap between the minority who understand the analytical tools and the majority who do not.⁷³

It should be noted that the design process may involve the research approach at certain points where new discoveries are needed or where the analysis of existing phenomena is needed.

The foregoing comments regarding the use of analysis in the design process apply equally well to the planning process.

Decision making can be dichotomized as the formulation of policies and the development of plans. With this usage, policies apply in static situations, i.e., where the same type of decision problem occurs repeatedly. Where this is the case it may be economical and advisable to develop a standard solution to the problem situation which can be applied each time the situation arises. Planning applies to those

⁷³ *Ibid.*

dynamic problem situations which are not repeated in similar form over time, where the transient is the rule. Management science has not begun to meet the challenge of these kinds of problems. Its achievements are primarily in the areas of policy and control. Planning has received much less attention.⁷⁴

The challenge to management science has been stated as follows:

Here then is the challenge to the 'scientific planner' in his relation with the managers and executives of his business organization. His methodology, his data, his hardware and computers are significant tools but not vital elements for his successful progress. He needs as much really to know, to understand, to respect, to integrate voluntarily with his co-workers in both manager and non-manager ranks, as he wants such relationships reciprocally from them. He has to be on the team with them to achieve such relationships.⁷⁵

Despite its limitations, there are many contributions which management science can make to the field of institutional planning. Some of these will be briefly described in the following paragraphs.

The techniques of quantitative analysis can and do play a significant but limited role in planning. They are especially useful in the comparison of alternative courses of action in situations involving criteria susceptible to quantitative measurement. Certain mathematical programming techniques may be useful for seeking optimal solutions in problem situations which can be described quantitatively. Also, the theory of games may help gain some insight into and understanding of strategy decisions.

Systems engineering is concerned with the analysis, improvement,

⁷⁴Starr, Martin K., "Planning Models," *Management Science*, Vol. 13, No. 4, December 1966, pp. B115-B141.

⁷⁵Smiddy, Harold F., *op. cit.*, p. 9.

and design of man-made systems for producing items or services of value to mankind.⁷⁶ Formal systems engineering is usually applied only in complex systems problems involving many components and/or intricate and complex interactions among components. Its emphasis is upon the analysis of component interactions and their integration in a manner to achieve the system's purpose effectively and efficiently. One statement of the systems engineering approach is as follows:

- (1) Define the problem.
- (2) Select objectives.
- (3) Synthesize systems for accomplishing objectives.
- (4) Analyze systems.
- (5) Select the best alternative.
- (6) Plan for action.⁷⁷

Traditionally systems engineering has been applied to the operations of physical systems. However, in recent years, economic, psychological, social, and other aspects of systems operations have been introduced into systems engineering applications as methodologies permit.

The parallel and similarity between systems engineering and planning are apparent from the above description. The primary differences seem to stem from the fields of application, the emphases, and the key participants. For example, one of the main differences is the

⁷⁶In the present context, a system might be defined as a set of resources, their interrelationships, and a source of intelligence developed for some purposeful function.

⁷⁷Hall, Arthur D., *A Methodology for Systems Engineering*, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1962, pp. 89-90.

heavy emphasis on quantitative and mathematical methods in systems engineering. Systems engineering in its present state, however, is not synonymous with institutional or corporate planning, and is not adequate for the task of such planning.⁷⁸ This may be true if for no other reasons than the frequent lack of sufficient study and data for the application of the methods of systems engineering. However, these techniques and approaches are useful in obtaining partial answers for certain aspects of the planning process. Also, the basic concepts of systems engineering can be useful to management in the thinking processes and intellectual efforts required in planning.

One example of a technique from the general field of management science which offers significant value in planning is computer simulation models. These models can be used to help predict the consequences of assumptions, alternative methods or designs, and changes in the values of various parameters. They can be used to investigate the sensitivity of outcomes to the uncertainties believed to exist.

Many other types of models may be of value in planning, e.g., mathematical models such as those of engineering economy, linear programming, and inventory theory. One of the primary difficulties with these models is the lack of adequate data relative to future operations.

Mathematical refinements of the traditional budgetary approach have been suggested. Some of these are extending the time horizon,

⁷⁸Branch, *op. cit.*, p. 147.

introducing probability, discounting to present worth, and predicting the multi-dimensional, non-linear behavior of cash flows.⁷⁹

Abstraction and conceptualization are very important in planning; thus, several types of modeling are important.

Skill in modeling involves a sensitive and selective perception of management situations. This in turn, depends on the sort of conceptual structures one has available with which to bring some order out of the perceptual confusion. Models can play the role of giving structure to experience.⁸⁰

As indicated previously, the achievements of management science have been primarily in the areas of policy and control. There are several reasons for this. First, because of the repetitive nature of these types of problems, historical data required for analysis and for various management science models are usually available. Second, even small improvements derived from the application of management science in a repetitive situation can add up to significant improvements over time. Also, repetition enhances learning and permits correction and improvement in the application of approaches and techniques.⁸¹

A program of needed research in planning has been described in the literature.⁸² The following selective outline taken from this description indicates some of the broad areas needing research and some specific topics under each.

⁷⁹Goetz, Billy E., *op. cit.*, p. 1.

⁸⁰Morris, William T., "On the Art of Modeling," *Management Science*, Vol. 13, No. 12, August 1967, p. B708.

⁸¹Starr, Martin K., *op. cit.*, p. B138.

⁸²Ansoff, Igor H., and Richard C. Brandenburg, *op. cit.*

Concepts and Methodology

- Tests of relevance and applicability of existing management science models
- The application of decision analysis models and utility theory
- Methodologies for the evaluation of plans
- Realistic computer simulation models
- Dynamic decision analysis models
- Methodologies for the search for information and for generating alternatives

Social Behavior

- Study of goals and objectives and how they should be formulated
- Task oriented organization theory
- Organizational adaptability to change
- Organizational acceptance of plans

Applied Theory of the Firm

- Studies of firms' behavior under various circumstances, to determine
 - success and failure patterns
 - effects of external conditions and product technologies
 - differences between internal functions
- Effects of computer on internal management structure
- Effects and formulation of various management attitudes
- Dynamic theory of the firm
- Interdisciplinary models; economic, social, and informational
- Relation of firms to environment
- Designing and installing data gathering systems
- Planning experimentation

Design of the Planning Process

- Adaptation and application of decision analysis models
- Adaptation and application of performance scheduling and control models
- Model integration
- Application of the computer
- Adaptability and flexibility of the planning process
- Tailoring planning system to the needs of firms

Organizational and Information Systems Design

- Task oriented organizational design
- Organization for change
- Dynamic organizational planning
- Organization of the planning group
- Design of planning information systems
- Development of planning procedures which enhance acceptance

It is emphasized that research in planning should be characterized by "realism" rather than by "formalism."⁸³

Organization for Planning

Planning is one of the primary responsibilities of management. Although this has always been so, trends in today's society are bringing a need for increased and more specific attention to the requirements for effective planning. In many cases these requirements include special organizational arrangements. This section will discuss some of the main considerations in organizing for planning.

The staff of a modern institution typically includes a relatively large number of professionals in various specialized fields. These professionals make decisions, almost routinely, in their work which significantly affect the future of the institution. Two basic requirements for the effective functioning of such an organization are: (1) the direction, goals, and expectations must be known throughout the organization, and (2) top management must know the decisions, commitments, and efforts of the people in the organization. The long-range plan can be a mechanism and framework for accomplishing these two requirements.⁸⁴

The initiative and support for institutional planning must come from top management. Planning should be viewed as a continuous and integral part of the managerial function. Top management determines the general objectives and policies, although the details and more specific

⁸³ *Ibid.*, B237.

⁸⁴ Drucker, Peter F., *op. cit.*, p. 242.

objectives and policies may be developed at lower levels.⁸⁵

In the typical modern organization, having a high content of professional and specially trained personnel, the active participation of all levels of management in the planning process is essential.⁸⁶ This participation will lead to better planning, more loyalty, and increased managerial effectiveness.

Sophisticated planning approaches or schemes for participation will probably not compensate for managerial deficiencies in other areas. Regardless of the planning effort, these other deficiencies can cause failure to achieve goals. It may be advisable to correct major managerial deficiencies before undertaking a large planning effort.⁸⁷

In analytical and academic activity "planning" and "managing" (operating, or "doing") are often treated separately. There is a tendency in some circles to try to translate this separation into an action principle, and to treat them as separate jobs. This sometimes carries with it the dangerous concept of an elite, intellectual group which does the planning remote from the operations of the institution. Planning and doing are separate parts of the same job, not separate jobs.⁸⁸ It may be useful or necessary, however, to have a distinct organizational unit staffed by various technical and specialist planners to provide staff support to the planning function.

⁸⁵ Branch, *op. cit.*, p. 74.

⁸⁶ Drucker, *op. cit.*, p. 242.

⁸⁷ Ewing, David W., *Long-Range Planning for Management*, *op. cit.*, p. 51.

⁸⁸ Drucker, *op. cit.*, pp. 8-9.

Many ways of organizing for planning are described in the literature. One example involved a planning committee chaired by a vice-president; the membership consisted of selected subordinates of all of the vice-presidents, serving on a part-time basis. This committee first formed a general strategy; then, subsequent to approval by the president, special sub-committees were formed to investigate the various aspects of the strategy. Although this committee obtained generally good results, some significant difficulties were experienced. One difficulty was the conflicting demands of immediate operational problems and planning problems on the time and resources of committee members. Another difficulty was a lack of good communication between committee members and the various vice-presidents who were making decisions affecting long-range plans. The failure of the various sub-committees to effectively share information and coordinate their efforts was also a problem.⁸⁹

An alternative arrangement would be to make the planning committee full-time by temporarily withdrawing its members from their operational responsibilities. The advantage would be that plans could be developed in more detail, faster, and probably more effectively and efficiently. A probable disadvantage would be the vice-presidents objecting to line personnel being removed from their staffs. Also, these people would be identified as staff men and might thereby lose some of their influence with line managers.⁹⁰

⁸⁹Ewing, David W., *Long-Range Planning for Management*, op. cit., p.150.

⁹⁰*Ibid.*, pp. 150-158.

One particular company created a vice-president for planning and administration who chaired a planning committee composed of all the other vice-presidents. Subcommittees were appointed for various projects, with a vice-president chairing each. Subcommittee membership consisted of other vice-presidents and company officials. An assistant vice-president for planning was made an ex officio member of each subcommittee and given the job of coordinating their activities. Eventually, standing subcommittees were formed to conduct planning in the various functional areas. For example, a subcommittee for facilities was formed which reviewed all projects concerning the company's physical plant and equipment. One of the primary advantages of this approach was the serious attention and priority given to the various planning projects by the top line personnel.⁹¹

One of the most serious problems in staffing for planning is the conflicting demands of operational and planning activity. Executives' schedules are usually very crowded with operational problems. This is especially true if there are serious managerial deficiencies or other major problems within the institution. The managers may partially ameliorate these conditions by the establishment of a planning support function with a full-time staff. The work of the staff, however, should be viewed as supplementary and not as a substitute for the involvement and contribution of line management. The planning will probably produce few results if complete responsibility is given to a planning staff. Another reason for maintaining management's close involvement is that a

⁹¹*Ibid.*, pp. 150-158.

large part of the benefit of planning is derived from the managers thinking through the problems themselves.

Some of the characteristics and skills required of the planning staff are implied in the following observations:

Business planning at its best represents a happy combination of art and technique:

Insofar as planning is based on knowledge and experience, it calls for analytical ability, for no body of experience, no sets of facts or statistics should be accepted uncritically.

Insofar as planning requires the development of methods and procedures, it calls for skill and ingenuity.

Insofar as planning addresses itself to problems, it demands resourcefulness.

Insofar as it deals with people (and all plans are carried out by people), it requires an understanding of the forces which motivate human action.

Since all planning is based on some estimate of the future, it puts a premium on the qualities of imagination and foresight.

Finally, and above all, planning always calls for the exercise of judgment.⁹²

Because of the many types of problems which must be handled, and because of the nature of planning as a process of change and adjustment, two of the main requirements of the planning staff are personal adaptability and analytical flexibility.

The professional planner, whether he be a full-time employee or a consultant, would be expected to provide the following types of assistance to management:

⁹²Bursk, Edward C. and Dan H. Fenn, Jr. (Ed.), *Planning the Future Strategy of Your Business*, McGraw-Hill Book Company, Inc., New York, 1956, pp. 50-51.

- (1) the stimulus to think systematically
- (2) a conceptual framework for decisions
- (3) guidance on likely outcomes
- (4) advice on organization for and the mechanics of planning
- (5) internal and external information and reports
- (6) techniques of analysis and evaluation
- (7) recommendations regarding decisions.⁹³

Some of the planning staff are likely to be specialists, such as economists, sociologists, and systems engineers. Specialists are characterized by the mastery of a particular area of knowledge not generally shared by other people. Because of this specialized knowledge, the specialist's advice is likely to be accepted uncritically since others usually do not feel qualified to evaluate it. The experience of the specialist is often in another field or an academic environment, and so he tends to bring a fresh and different way of looking at problems. His function usually consists of investigation and advice.

Behaviorally, the specialist may tend to view his activities, special approaches, and interests as ends in themselves; his concern for the "real" problem, therefore, may not be as great as that of the non-specialist. Also, the specialist may not view his association with the institution as a long-term matter, but rather as an arrangement for providing an environment and the resources to practice his specialty.⁹⁴

Specialists are usually expected to be instrumental in originating ideas, providing certain types of data and information, and evaluating data and alternatives. Their roles and responsibilities are

⁹³Perera, John, *op. cit.*, p. 42.

⁹⁴Lebreton, Preston P., and Dale A. Hemming, *Planning Theory*, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1961, pp. 231-2.

expected to be minor in areas such as authorizations and approvals, integration of plans, management of the planning process, and implementation of plans.⁹⁵

In many cases management finds it difficult to use specialists effectively. This difficulty will probably not occur, however, if certain conditions are met. First, there should be a real need for the particular talents and skills which the specialist has to offer. Second, management must be willing and able to adjust to the logical demands of the findings of the specialist, and to support him in his work. Next, management must use good judgment in accepting and applying results of the specialist's work. Also, it may be desirable for management to exercise fairly close coordination and constructive control over the specialist in the early stages of his employment, at least until he becomes familiar with the operations of the institution and its environment.⁹⁶

Some of the major problem areas in organization for planning are as follows:

(1) Dangers of Exclusiveness. Where the planning group is divorced from operations, many disadvantages may develop. The planners may lose contact with the immediate dynamics of the operation concerned. Middle and lower management may not develop a good comprehension of long-term goals and objectives. Also, a vast reservoir of knowledge and experience in middle and lower management which would be helpful

⁹⁵ *Ibid.*, pp. 248-9.

⁹⁶ *Ibid.*, pp. 248-9.

in planning is left untapped. And finally, these managers may not accept the work of an isolated planning group.

(2) Line-Staff Myopia. The distinctions between line and staff positions are many times overplayed. A look at any particular organization and its operations will reveal significant overlaps among line and staff functions. Attempts to apply strictly a sharp distinction between line and staff positions may hamper planning.

(3) Preoccupation with Operations. Immediate problems may demand so much of the time of managers that they pay inadequate attention to planning.

(4) Inflexibility. There may be great resistance to change within the institution. Few organizations have adopted the philosophy that change is fundamental, or have explicitly recognized change as a condition of survival over the long run.⁹⁷

Three important lessons regarding persons directing planning activities are as follows:

(1) The planning work should be directed by someone in continuous or frequent contact with managers in the various functional areas.

(2) The person in charge of planning should have proven ability to take normal calculated risks.

(3) The person in charge needs a particular kind of temperament.

⁹⁷Ewing, David W., *Long-Range Planning for Management*; (See "For LRP-Rotating Planners and Doers," by Ronald J. Ross) p. 194.

Objectivity is a key factor. He must be willing to let the chips fall where they may.⁹⁸

While staff specialists and consultants are similar in many respects, their differences are important. Outside consultants, even though some may be specialists, usually have considerable experience in the fields in which they are consulting. Although some may be engaged because of their knowledge of and skill in applying a particular technique or approach, their primary contributions are usually the transfer of knowledge, ideas, and information from experiences on similar jobs, and providing certain judgments, recommendations, and advice based upon this experience. Their roles, although sometimes critical, are normally limited in scope; the most important results of planning are derived from internal efforts. A common mistake is indicated in the following quotation:

Consultant firms have been retained in costly attempts to obtain from the 'expert from out of town' the kind of analytical appraisal and specific recommendation which are so integral a part of the business's operation that considerable internal capability and accomplishment are essential before worthwhile benefits can be expected from external scrutiny.⁹⁹

Two frequent disadvantages of the use of consultants are high costs and lack of continuity.

One of the first questions to be answered in developing organizational arrangements is, how far down the organization structure should formal planning go? In other words, how many levels of the organization

⁹⁸*Ibid.* (See "Steps in Long-Range Planning," by Bruce Payne), pp. 216-238.

⁹⁹Branch, Melville C., *op. cit.*, p. 65.

structure should be formally represented in the planning process, through planning committees or otherwise? The "point of diminishing returns" may be reached above the lowest organizational unit.

Since the plans developed at one level in the organization become constraints on the planning at lower levels, the sequencing of planning operations and the development of good communication are important considerations in designing the planning organization and procedures.

It is usually advisable to make specific responsibility assignments for planning. The scope of the assignments at each level should not exceed the range of activity and decisions involved in the normal functioning of that level.

Another important decision to be made, which relates to all of the above considerations, is the amount of resources to be devoted to planning. Such resources include the time allocation of management and the expenditures of funds on consultants, special staff, supporting services, and supplies. Although it may be more difficult and uncertain, the decision regarding the allocation of resources to planning is similar to other investment decisions where expected costs must be compared with expected returns.

Conclusion

In conclusion, it might be said that managers of all institutions must make decisions with long-range impact. The important questions are: To what extent should they make special preparations for them? What should these preparations be? And, what formal arrangements for planning are needed?

This chapter has described several considerations relative to these questions. In summary, planning is necessary because of changes, particularly changes brought about because of advancing technology. There are several different types of planning, each having its distinguishing characteristics and requirements. Each of these types will probably be involved to some degree in institutional planning. Planning is a function of management; it should be action-oriented. It is a creative process. Its basic steps involve setting objectives, making required assumptions, developing alternative courses of action, evaluating the alternatives and selecting the desired one, implementation, and evaluating results. The management of planning is an important aspect of the process, and involves organization, information development, communication, and scheduling activities. The development of an approach to planning involves the selection of an appropriate mix of the "outside-in" and the "inside-out" approaches, a scheme for handling uncertainty, and techniques, such as those of management science. Important behavioral considerations in planning include the frequent resistance to and lack of familiarity with this type of activity, the political content of most planning processes, and the personal characteristics required of the planning staff. These characteristics of the institutional planning process influence the potential role of management science, but it appears that, in most cases, management science could play a significant role.

Planning for facilities involves all of the above considerations. A distinction is being made between the planning of facilities and the

planning *for* facilities. The planning *of* facilities might be considered a technical, engineering, and architectural process. The planning *for* facilities is institutional program planning and functional planning derived from strategic and long-range planning, which must precede the planning of facilities. The interaction and overlap of these two types of planning and their effects on the potential use of management science principles and techniques are the subjects of the following chapters.

All of the areas of needed research in the field of planning indicated above appear to be especially needed in the planning *for* clinical facilities for medical education, as well as many other areas in the planning *of* clinical facilities not yet mentioned. The following quotation indicates the nature of the interaction of these two phases of planning and their complexity:

Planning a new multi-divisional facility is illustrative. Operational requirements must be developed by those who will use the establishment. Each has special problems and desires. The many different specifications relating to location, space, equipment, and people must be integrated to meet the limitations of the project budget, financing, architectural-engineering and construction requirements, maintenance costs, and future rearrangement and expansion. Conflicts and inconsistencies must be resolved. Corporate interests and objectives must be presented and the efficient functioning of the total establishment insured, since the whole is more than the sum of its parts. Such project planning is a management task of representation in the fullest sense of the word. Either a 'prima donna' approach by the executive in charge of master planning, or his acceptance of all declared requirements in an effort to make everybody entirely happy, of course results in an unsuccessful facility.¹⁰⁰

¹⁰⁰ *Ibid.*, pp. 169-170.

CHAPTER IV

ENVIRONMENTAL BACKGROUND

Introduction

The planning for clinical education facilities includes elements of governmental, community, comprehensive health, institutional, and hospital planning. This chapter describes the major characteristics of the institutional and managerial environments of clinical education programs relevant to the planning process and the potential use of management science techniques in planning.

Formal strategic and long-range planning was almost non-existent in the health field until recent years, and even now it is in an infant stage. The lack of formal planning in the health field is not surprising when considered in the light of 1) the history of other types of planning in this country, 2) the history of the development of the medical field and its technological advancement, and 3) the nature of the profession of medicine and the traditional methods of delivering health care.

As was previously mentioned, only in recent years has planning been accepted by managers in this country as a function worthy of specific and formal attention. This is probably due to the existence of certain ideological viewpoints, as well as a relatively lower "need" for formal planning in earlier years. In recent years the need for planning has increased and is more generally recognized, and some of

the ideological viewpoints are more relaxed. Although planning in the health field may be somewhat less advanced than that in other fields, it could not be too far behind in years from a historical point of view.

One factor which may have retarded the development of planning in the health field is the basic nature of the health care industry and the role of the profession of medicine. The physician's training, method of practice, philosophy, and economic arrangements are based on the inviolable one-to-one relationship of the patient and his doctor. Anything which threatens a change in this relationship is usually strongly resisted by the profession. These considerations usually result in philosophies and practices opposing the corporate practice of medicine, government intervention or control, or any form of strong organizational management. Since planning is considered to involve some form of management, control, or even some indirect influence and restraint on the physician, his mode of practice, and his professional aspirations, it has in many cases been neglected, avoided, resisted, or even vetoed.

One of the primary factors in the increasing need for an acceptance of planning in recent years is the rapid advance of technology and the consequent high investment in facilities and personnel which often can be justified only on a regional basis. Thus, the increasing need for planning in the health field develops.

After World War II some attention began to be directed toward the planning of hospitals. At first this amounted to little more than a recognition of the need to avoid duplication of hospital facilities

in an area, and the need to plan the number of beds based upon the projected demands for health care in the community. Further emphasis was placed upon the planning and design of hospitals by the passage of the Hill-Burton legislation. In recent years, hospital planning in particular has become more widespread and more sophisticated. There is relatively little evaluated evidence, however, of the success of these efforts.

Planning on a broader basis than just hospital construction was initiated and promoted by the government through legislation establishing the Regional Medical Programs and Comprehensive Health Planning. Although it seems reasonable to assume that Federally-sponsored planning programs are here to stay, it is still unclear just what the nature of these programs might be. Among the possible directions these programs might take are the following:

- (1) Planning in its broadest sense, including the various types of planning and all of the steps described in the previous chapter.

- (2) Administrative and financial control; e.g., authority of review and approval of requests for funds, to prevent duplication and waste.

- (3) Providing financial support to promote planning by local and regional agencies.

It seems likely that, regardless of the specific directions of development of these programs in the future, considerable local initiative and effort will be required in order for the planning to be successful.

The institutional effort required in planning clinical facilities for medical education must include elements of the broad spectrum of planning in the health field, as well as other elements of planning peculiar to educational institutions. Clinical facilities are service facilities, and therefore should be planned as a key element in the health-service programs of the region. However, the institution's primary objectives involve education, and are not always operationally compatible with service needs. The conflicts among service, educational, and research objectives, the rapidly advancing medical technology, the complex and largely uncoordinated organizational arrangements, and the lack of good and clear measures of success create a complex environment for the planning of clinical education facilities. The following sections will further elaborate on certain aspects of this environment and their effects on the planning process.

Medical Education

Many types of students in the health field receive parts of their training in clinical settings. It appears, however, that the educational requirements of physicians are dominant in most major aspects of planning for clinical education programs. Therefore, this section will emphasize characteristics of medical education which are important in the process of planning for clinical education facilities.

The professional education of physicians usually begins after four years of college and consists of four years of medical school, one year of internship, and two to six years of residency depending upon the specialty chosen. The first two years of medical school involve

education in the basic life sciences, including anatomy, pharmacology, bio-chemistry, and microbiology. They may also include limited exposure of the students to patients, primarily to demonstrate the relevance of the basic sciences to medical practice. Most instructional sessions during this period take place in classrooms and laboratories.

The last two years of medical school involve clinical training, i.e., direct exposure to and experience in the care of patients. Most of this training is on-the-job training in the teaching hospital. The training periods on individual subjects are referred to as "clerkships." During a clerkship students are assigned patients to "work-up" and follow throughout their stay in the hospital. The students take patients' histories, examine the patients, request certain tests, and prescribe certain treatments, all under the close supervision of the "house staff" and faculty. Much of the work performed by students as training exercises is duplicated by the house staff and faculty. In addition to hospital inpatient experience, the last two years of medical school include outpatient care, off-campus experiences, and special study and research electives.

The general approach in clinical training seems to be to expose the students to a broad spectrum of cases and to all of the basic specialties in medicine. Some elective time is allowed for the students to follow their own interests. The primary objectives in clinical training involve having each student:

- (1) Gain basic and general knowledge of medicine, its history and approach, and its specialties.

(2) Learn the scientific approach and develop the ability to apply it in practice.

(3) Prepare for continuing education throughout his professional life.

(4) Identify the fields or specialties in which he is most interested.

(5) Learn enough about all of the basic areas of medicine to justify his being called a "doctor."

The internship consists of one year of clinical training in a teaching hospital to prepare the graduate physician for further specialty training or for general practice. One pattern of training for interns is a rotation through all of the basic medical specialties; this is likely to be the case for those who plan to go into general practice. The nature of their training in this pattern is similar to that of the clerkship, except that their responsibilities and involvement are greater. The other pattern consists of one or two specialty areas which complement the area selected for residency training.

The residency is the period of specialty training for physicians; it also take place in a teaching hospital. The lengths of residencies are from two to six or more years, depending upon the specialty chosen. Residents are responsible for the day-to-day medical care functions and medical management on the units to which they are assigned, under the general supervision of the staff physicians or faculty. In a medical school hospital the residents play a major role in teaching medical students, and, if the hospital is primarily an indigent, referral type, they may assume most of the responsibilities for accepting patients for

admission to the hospital and arranging for their care. In other hospitals the residents are usually less involved in teaching and admissions; their role consists primarily of carrying out the orders of the patients' regular physicians and managing the patients' care in the absence of the regular physicians.

Facilities for the first two years of medical education are primarily classrooms and laboratories similar to those required for science students in other types of curricula. There are some special features required, however, such as those for anatomy and animal surgery. Clinical training requires primarily hospital facilities, both inpatient and outpatient, with some special features to accommodate the educational function, e.g., conference rooms, study areas, and laboratories. Popular rules-of-thumb indicate that three or four hospital beds are required for each student in clinical training. There are no similar rules or indicators for outpatients.

Medical students in their clinical years take clerkships offered by the various clinical departments. Some of these clerkships are required, others are elective. Some have prerequisites, but a large number do not. The required clerkships are usually taken during the first year of clinical training.

Students usually take only one clerkship at a time; therefore, they are split into groups and scheduled for their required clerkships in a manner which will distribute them evenly throughout the basic clinical departments and throughout the year. Some electives are taken during the first clinical year, but most are taken during the last year. Typically, the first year emphasizes inpatient programs, with

outpatient experience coming in the last year.

Until recent years medical schools operated on a full-scale basis only nine months out of the year, from September until June; a small number of students might be involved in research projects during the summer. Recently, they have moved towards a 12-month operation. Under this mode of operation, at any time during the year approximately 75 per cent of the students are in formal training and the others are on vacation or non-credit activity. Of the 75 per cent in formal training some may be on electives at other institutions. The number of students taking electives at other institutions will depend on many factors, including (1) the policy of the medical school, (2) the capabilities and characteristics of the medical school and its teaching hospital, (3) the affiliations of the medical school and its teaching hospital, and (4) the geographical location of the medical school.

There is much discussion among medical educators of the possibility of and need to eliminate the internship since most of its initial purposes are now accomplished by the clerkships, and most of its present activities are very similar to the first year of residency.

At the present time residency programs are instrumental in the clinical training of medical students. Residents manage the patient care programs of the teaching hospital and provide a large part of the supervision and training of medical students in their direct experience in the patient care process.

The relationship of the residents and the medical school faculty may be considered analogous to the relationship of graduate students to

the faculty in other types of schools. The residents are students as well as practitioners in the various specialties in which the faculty members are professionally and academically interested. As the most advanced students, they serve to stimulate the faculty, assist them in patient care investigations and research, and relieve or support the faculty in many patient care and teaching functions. The residents are on a high level professionally and technically, and therefore are more interesting and challenging students for the faculty. Moreover, the residency programs are the only educational programs from which the graduates go directly into the practice of the specialties in which the faculty members are primarily interested. Therefore, the requirements of residency training are very important to the faculty in planning for future clinical education programs.

Residency programs are developed and sponsored by the various clinical departments of the teaching hospital. They are reviewed and approved by a review committee which is staffed and controlled by the national specialty board representing the specialty of the particular residency program in question. It is likely that each residency program in a particular hospital will be subject to review and approval by a different review committee. The standards for various residency programs are not uniform and are in many ways uncoordinated.

The review committees use certain general standards in evaluating residency programs. Some of these standards are quantitative, or at least imply minimal levels of operation or patient-care exposure. For example, a given residency program may require a certain number of beds,

cases, outpatients, deliveries, operations, etc., per resident per year. While these standards are necessarily important considerations in planning clinical programs, they are not integrated and coordinated in a way such that their application alone will lead to an effective and efficient program either for medical education or hospital operation. The integration of these standards and criteria with those for medical student education and hospital operation becomes a critical aspect of the planning process.

The number of residents which can be trained in a particular hospital is limited by the level of patient care activity in that hospital. Conversely, to support given numbers of residents in its various residency programs, the teaching hospital must attract an input of patients sufficient to generate the required level of patient-care activity. The latter seems to be the direction of planning in the medical school teaching hospital.

The relationships among the medical student programs, residency programs, and faculty activity and interests are often very complex and indefinite. For example, (a) there are no clear, accurate, and objective standards regarding the clinical exposure required for medical students in the various specialties, and therefore there are no such standards for the number of residents required to support a medical student program of a particular size; (b) the medical student curriculum is in the process of intensive investigation and change; therefore, the levels of activity in the various specialties are not fixed and cannot be predicted with confidence; (c) the size of the faculty required is a function not only of the number of medical students, but also of the

number of residents, service obligations, and research activity; (d) research activity is a function of faculty interests and capabilities and governmental support; and, (e) the residency programs are a function not only of the medical student programs, but also of the service obligations, faculty interests, specialty board requirements and institutional objectives.

It has been stated that the requirements of residency training are dominant in planning clinical education programs and facilities. According to one view, the types of patient care programs and levels of activity are largely determined by the requirements of the residency programs; medical student programs will satisfactorily "fit into" the clinical programs designed for the residents. One problem with this position, however, is that in many cases the medical school has no official charge for the education of residents. The official charges and the funding are usually related more directly to medical students. A lack of clearly stated objectives and policies regarding the residency programs can cause confusion and inconsistency in clinical program planning.

Because of a projected worsening of the physician shortage, there is presently strong pressure on medical schools to expand enrollment. Such expansion, however, is a slow, complex, and expensive process, due to the requirement for hospital facilities and clinical programs and because of the low student-faculty ratio common in medical schools. Some idea of the expense involved in just the hospital facilities and clinical programs can be obtained by making a conservative estimate of the cost per bed of teaching hospital construction at \$30,000 and

multiplying by three beds per student, resulting in an estimated capital investment of \$90,000 per clinical student. The hospital operating cost per bed may be conservatively estimated at \$18,000 per year. Assuming a typical 50 per cent collection rate on teaching patient charges, the net cost per year per student to the institution is approximately \$27,000. Additional costs include faculty, housing, classrooms, laboratories, and other student activities.

As mentioned above, the medical school curriculum is presently undergoing a process of critical review and change. In the clinical years the traditional curriculum consists primarily of departmental clerkships and electives in the departments of medicine, surgery, obstetrics/gynecology, pediatrics, and psychiatry. While the students are in the clerkship of a particular department or specialty they are exposed to those aspects of diseases and abnormalities of interest in that specialty. It is claimed that since the clerkships are primarily departmental and specialty oriented, and since the instructors are primarily specialists, the students do not get the "total systems" picture of the disease or abnormality; i.e., they are not presented a comprehensive, integrated view of the case.

Systems-oriented curricula are being developed in order to overcome some of the apparent deficiencies of the traditional methods. In such a curriculum, the students would be taught to view diseases and abnormalities in the context of the physiological systems in which they occur and in the context of a systems-analytic view of the disease process itself. This is carried further than just the technical aspects

of the disease, its process, and the physiological system involved, and includes the sociological and psychological aspects as well.

At the present time the primary structure of the systems-oriented curriculum is multi-disciplinary clerkships. These clerkships integrate the exposure of the student to the various aspects of the disease process and the physiological system over time and attempt to integrate the conceptual viewpoints of the various disciplines and specialties. An example of a multidisciplinary clerkship is one which integrates obstetrics, pediatrics, and psychiatry in training students in the care of mothers and their newborn babies. Another one integrates medicine and psychiatry.

Another factor influencing medical school curriculum changes is the increasing diversity of the entering students. In past years the academic backgrounds of entering students were more homogeneous (usually in the liberal arts) and their objectives regarding professional practice were more standard (usually general practice). Now students enter from many different backgrounds, e.g., liberal arts, chemistry, mathematics, engineering, and physics. Also, their objectives are as varied as the many specialties which exist today; very few plan to go into general practice. This diversity of background and objectives creates the need for a flexible curriculum which provides more electives and multiple tracks for the students to follow.

These trends and changes in medical school curricula may have significant implications for resource requirements, including clinical facilities, at the medical school. They imply changes in the types of

patient-care exposure and amounts of each to be involved in the educational programs. They will also affect the number and types of hospital beds, the nature and extent of outpatient facilities, and the location and design of educational space such as study areas, conference rooms, and lecture rooms. The larger number of electives and the larger amount of elective time may require more excess capacity and more flexible facility designs.

The virtual explosion of technical knowledge in the medical fields in recent years has contributed to a proliferation of and increased emphasis upon the medical specialties. Most medical school graduates go into some specialty. Many educators claim that this increase in technical knowledge and specialization has outdated the general practitioner (GP). Whether this is true or not, the relative number of GP's is decreasing rapidly, and there is growing concern over the shortage of generalists or "primary physicians" in the health field. There are relatively fewer physicians available for and interested in first-line contact with the patient population, the care of patients with routine and relatively simple ailments, and the screening function including initial diagnosis and referral to specialists. For these reasons, it is more difficult for the patient to enter the health-care system and to receive the proper care at the right place and at the right time.

Changes in technology and medical economics are creating problems, pressures, and opportunities regarding the health-care delivery systems in this country. The general need is to create an improved health-care delivery system which will rapidly and effectively carry to

application the many results of medical research and technological advancement. There is also the problem of rapidly increasing costs of health care, which apparently can only be curbed by innovative improvements and new designs in health-care delivery systems. Educational institutions attempt to contribute to the solution of these problems by the appropriate education of its students and through the development and demonstration of model systems. Therefore, these considerations are important in planning for clinical education facilities.

Not all medical student training must take place in the medical school's own hospital. Most medical schools are affiliated with other institutions to obtain resources for portions of their educational programs. Affiliation arrangements may involve political, economic, and medical elements. They help prevent expensive duplication of clinical facilities and programs and contribute to the diversity of experience available to the students and faculty. The development of affiliations is a complex and vital phase of planning for clinical facilities for medical education.

Another alleged problem with medical education today is its heavy orientation toward the acute stage of medical care within the hospital. Non-hospital practice, e.g. outpatient and home care, has received little emphasis. Many educators feel that this is inappropriate for the educational process since much of the physician's practice involves extant hospital services. Also, it may be that this heavy emphasis on hospital practice in the physician's training causes him to be hospital oriented in his practice after graduation and results in over-utilization of

hospitals as well as inadequate practice in other ways. The move of many medical schools towards general outpatient programs, community medicine, etc., attempts to improve the balance in this respect.¹

The Medical Center

A university medical center used for training in medicine and the allied health professions usually consists of the teaching hospital, clinics, and research facilities. Typically, these facilities and functions are closely related geographically and organizationally to the other elements of the university which are involved in health education. This is especially true of the basic science and clinical departments which are involved directly in the education and training of medical students. The close relationship of these two fields is felt to be one of the most important factors contributing to the present alleged high quality of medical education in the United States.

In many cases the teaching hospital is, for all present intents and purposes, owned and operated by the educational institution. In other cases, the institution obtains clinical programs and facilities for educational purposes through affiliations with hospitals which are owned and operated by other organizations, typically a city, county, or

¹It should be noted that not all medical educators agree that the relative emphasis on acute and specialty care in medical school should be changed. One viewpoint on this subject is that the physician must obtain training and experiences in these types of medical care in some way, and that the best, if not the only, way is through his medical school training. The skills and experience needed for the more common and routine aspects of medical practice are relatively easier to obtain through actual practice than are the skills and experience needed for handling acute, complex, and special cases. Therefore, the medical school should emphasize training of the latter type.

the Veterans Administration. This discussion will be limited to the case in which the teaching hospital is owned and operated by the educational institution; however, most of the considerations to be discussed are the same for both cases. The term "teaching hospital" will be used hereafter to refer to the full array of hospitals, clinics, and clinical research functions and facilities which make up the medical center.

In some cases the teaching hospital is under the control and direction of the dean of the school of medicine. In other cases, the hospital administrator and the dean separately report to the same provost or vice president who is responsible for coordinating the hospital and educational programs. The clinical faculty of the school of medicine typically make up most of the medical staff of the hospital; however, some private-practice physicians may be on the staff of the hospital and perform part-time teaching functions. The chairmen of the clinical departments in the school of medicine are usually chiefs of the corresponding services in the teaching hospital. The medical director of the hospital is frequently the dean of the school of medicine or is on his staff.

The functions of the medical center include education, research, and service. The educational programs which appear to receive the most emphasis and to have the most influence on the structure and operations of the medical center are those of the medical students and the residents. And, as was mentioned earlier, the nature of the residency programs and their requirements appear to determine more directly the characteristics of the clinical programs than do the medical student

programs. The importance of the residency programs, however, may not be reflected in the formal planning and budgeting procedures of the institution.

Other educational programs of the medical center may include dentistry, nursing, medical technology, radiologic technology, medical records, medical illustration, public health, and graduate studies. Many of the students receive portions of their training in the teaching hospital. The rapidly growing need for allied health personnel is resulting in increased emphasis on their training programs, larger numbers of students, and greater demands on resources. Continuing education is another element of growth in medical centers. The medical center is increasingly called upon to develop continuing education programs to keep practitioners up-to-date in the rapidly advancing knowledge and technology of the health field.

Research in the medical sciences has been one of the most important and fastest growing functions of the medical center in recent years. Advances in medical knowledge and methods resulting from these research efforts are well known. While producing results valuable to society, research has at the same time contributed to the development of the medical centers and schools of medicine. Research has influenced the directions and the emphases of the schools, and has been a large factor in financing their operations. The emphasis on research has influenced the types of facilities constructed, the types of faculty obtained, and thereby, the nature of the clinical programs and the educational programs of the students and house staff.

The school of medicine's commitment to and extensive involvement in providing immediate and direct services to people is an important distinguishing characteristic of its philosophy and operations. Few other schools (notably, dentistry) find it necessary to perform such a service function in conjunction with their educational and research programs. Basically, however, the objective of the service programs is to provide the clinical material necessary for educational and research programs.

The usual method of coordinating clinical programs with teaching and research needs is to have the faculty control the patient input to the hospital. In the typical case, most of the patients are sent to the university's hospital on referral from private practice physicians or health agencies. Most of them are referred for special services not generally available in the community. This arrangement is a natural one for several reasons, including the following: (a) in order to accomplish its educational and research objectives, the school of medicine must possess or have direct access to the full range of medical expertise, knowledge, and facilities, (b) the residency programs require specialty programs, and (c) the specialty referral population is one from which the input to the hospital can be more easily controlled.

The various functions and activities of the medical center are strongly interdependent. For example, most individual members of the clinical faculty are simultaneously involved in patient care, education, and research. Their patient care functions include hospital and clinic services; their research is both clinical and basic science research; and their teaching involves medical and allied health students in the

basic sciences and clinical practice. And medical students are involved in both the clinical and basic sciences, sometimes during the same training period. These interdependencies are important considerations in the development of program and facility plans which will result in a productive environment and economical operations.

The service function of the educational institution's teaching hospital may create problems of goals and priorities. Some educators and administrators question whether an educational institution should own and operate a hospital. Educational interests and needs may not be consonant with community service needs. Lack of consonance probably arises most clearly and most frequently in terms of the priority of objectives and the allocation of resources. Objectives of the school involve primarily teaching and research, and emphasize tomorrow's needs and desires. The objectives of the hospital must relate more directly to the provision of quality service to patients at the present time. While the objectives of the school and the hospital are certainly compatible in the long run, the short run operational problem of accomplishing them through the appropriate priorities and resource allocations is a significant and difficult one.

Another problem faced by the teaching hospital is the rapid change in medical technology and programs. The teaching hospital, in order to serve the required functions for the schools, must attempt to stay in the forefront in regard to technology and methods. Therefore, it must undergo a continuing process of alteration, adjustment, and investment in new programs and facilities in order to stay up-to-date. This process of change is also contributed to by the requirements of

meeting the changing needs and desires of the faculty and curricula of the schools. In addition, change is required to meet the increasing public expectations regarding the services provided by the medical center.

The management of the hospital as a unified organization directed toward a clearly specified and well understood goal is an extremely difficult if not an impossible task. In addition to the difficulty of developing effective operational goals for the hospital as a unit, there is the condition of the hospital being staffed almost entirely by various professional, quasi-professional, and trade groups. Typically, these groups have their own objectives, standards, and norms, the total of which does not always lead to a rational and effective hospital system; the groups do not always reflect the objectives and standards which are or should be those of the hospital as a unified organization.

One significant problem in the administration and management of teaching hospitals is the lack of explicit and meaningful cost responsibility. While the hospital administrator or director is generally considered responsible for the control of hospital costs, he usually has authority over only a part of total costs. The medical staff exercises control over a significant portion of hospital costs without having commensurate managerial responsibility for those costs.

The approaches and attitudes of the medical staff contribute to the difficulty of managing the teaching hospital in other ways. Most physicians, by virtue of their training and interests, are inclined to act independently rather than organizationally. Each is trained to rely primarily upon his own judgment and decision in medical practice. In

general, physicians are interested primarily in their professional practice and, in particular, their medical specialty. Without judgment as to whether these characteristics of the physicians are good or bad, it seems safe to say that they make the administration and management of teaching hospitals more difficult.

Some of these same characteristics, although less pronounced, are found within other groups of hospital personnel.

In recent years medical schools have been increasingly recognized as a significant resource capable of leadership with regard to many of the nation's health care problems. For example, the Regional Medical Program legislation placed medical schools in a central role in developing regional programs relating to heart disease, cancer, and stroke. It appears that the medical school and teaching hospital may be called on to provide services over and above those required for teaching and research. This will accentuate the problem of balancing programs and resources so that teaching, research, and service needs are met. Many educators feel that any significant growth in the service activities of medical schools will create a serious drain on the faculty and resources of the medical school, and thereby threaten the accomplishment of the primary objectives of the school.

There are at least three ways in which medical schools can contribute to improvement of the delivery of health services:

- (1) By studying how health care can best be provided.

- (2) By teaching medical students and young physicians practices which are effective medically and efficient economically.

(3) By providing models or demonstrations of health care delivery systems.

The function of developing, evaluating, and demonstrating models of health care delivery systems seems to be one of the primary ways in which teaching hospitals will emphasize their service role in the future. These new models of health care delivery systems require innovations in organization, facilities, and methods. Many will require a "team approach," as more and more of the service functions require non-medical as well as medical disciplines. The care function in the medical center is changing from a concentration on the treatment of acute, short-term, somatic disease to a more comprehensive system of delivery of care, including psychiatric illness, prolonged illness, emergency cases, special cases, health promotion, and disease prevention.

Other ways in which teaching and service activities are changing are in the development of new settings, including private wards, centralized outpatient departments, group practices, community health centers, home-care programs, clerkships with GP's, and small group teaching. Also, there is more emphasis on graduate and post-graduate programs and on continuing education.

New tools and methods are being introduced in the operation of the medical center through automation, data processing, programmed instruction, audio-visual aids, etc.

All of the above-mentioned changes and developments contribute to increasing complexity in organization, function, skill requirements, equipment, cost control, methods, and objectives.

In conclusion, certain generalizations regarding the probable role of the teaching hospital in the future seems appropriate. With regard to its teaching function, the hospital will provide a cross-section of patient care programs adequate for educating students in the various health fields, within operational systems reflecting high quality and excellence. The hospital will provide the clinical material necessary for the research programs of the schools, and will provide an environment which is both inspirational and productive with regard to research. In its service functions, the hospital will provide a focus of leadership in the development of improved health care delivery systems, will be involved in developing, evaluating, and demonstrating such systems, and will be a source of specialty services for the community and region.

Changes in the Health Field

The university medical center is an integral part of the health care system of the country. Its objectives, programs, and operations are greatly influenced by the changes and trends in the health field in general; therefore, these changes and trends are important considerations in the process of planning for clinical education facilities. This section will describe briefly some of the most important elements of change within the health field which impinge upon the medical center's planning process.

One of the most important elements of change is the changing expectations and demands of the public regarding health services. Increasing expectations and demands are resulting from greater

affluence, urbanization, education, and an awareness of the results of medical research as well as the application of science and technology in other areas. There has also been an increasing awareness of some of the social ills of the country, along with the growing opinion that something can and should be done about them. In addition to individuals seeking more and better services, the government has reacted by initiating the health programs of the "war-on-poverty," Medicare, and Medicaid. These programs have generated different and greater demands on the health-care institutions.

Governmental programs now cover a large portion of the population and have resulted in demands for health services which did not exist before. Through experience with these programs, the government and the public have become much more concerned about the rapidly increasing costs of health care. Public and governmental scrutiny has resulted in many studies, hearings, and publications regarding serious problems in the health care system of this country. There seems to be little doubt that governmental influence in this field will continue to increase. Some writers even predict that the health care system will be socialized in the future, or at least will be managed and regulated in a manner similar to that of the utility industries.

Another significant change is the declining role of general practitioners. Most medical school graduates now go into specialties rather than general practice. This increasing specialization and other factors such as changes in physicians' mode of operation are making it more difficult for patients to gain entrance to the health care system. As a

result, many people use the emergency room and outpatient clinic of the hospital as their source of medical care. The use of the hospital in this way has been increasing in recent years.

Other factors are also increasing hospital usage. More of a physician's practice now takes place in the hospital. Many of the special diagnostic aids, procedures, and treatments require sophisticated and expensive equipment as well as skilled personnel which are available primarily within hospitals. Also, special consultation and nursing services are available within the hospital. Insurance coverage is also contributing to hospital usage. It is claimed that many patients are unnecessarily assigned to hospitals in order to get insurance reimbursement for services received.

Several other changes are important considerations in structuring programs within the medical center which will expose the students to various modes of practice; e.g., the school may want the students to participate in group practice. In group practice physicians are organized into small groups containing various medical specialists which compliment each other in terms of the patients' needs; i.e., the most frequently needed consultations are available within the group. Usually the members of a group share the same facility and ancillary services. They also assist each other in taking "calls," vacation coverage, etc. The most important advantage, however, is the availability of a diversified team of complimentary medical specialists and allied health personnel which can provide effective, convenient, and efficient health care.

The Kaiser-Permanente program in California provides a different type of group practice which may reflect the direction of future changes and improvements in medical practice and health care delivery systems. This highly successful program provides complete health care services for subscribers on a pre-payment basis. Preventive medicine and health maintenance are emphasized. Periodic comprehensive health check-ups are provided. Physicians are employed by the program and share in the profits. Studies of the results of this program indicate that it is an efficient and effective way to provide health care to groups; e.g., the average number of days/year each person spends in the hospital is significantly lower than the national average and than the average for other similar groups.

The increasing emphasis nationally on preventive medicine and health maintenance may have significant implications for teaching hospitals. One example of a new health maintenance program which might be undertaken by teaching hospitals is the multiphasic screening clinic, developed by the Kaiser-Permanente program, in which "non-sick" patients undergo a battery of examinations and tests as a part of a routine check-up. These examinations and tests are performed by machines. Much of the information handling and data processing is performed by computers, and a report is printed out for the doctor prior to his examination of the patient. This report provides the doctor with information not normally available under usual methods of practice to assist him in a more thorough evaluation of the current health of the patient and in detecting early signs of abnormality. Multiphasic screening is

often provided as a part of a group insurance program at nominal cost to the patient.

The recent emphasis on regional health planning is already influencing planning and operations at teaching hospitals. The primary reason for this emphasis is the need for developing a better coordinated and a more effective and efficient health care system. Under the conceptual scheme usually proposed for such a system, the local practitioners, hospitals, and clinics provide the primary medical care services, i.e., the "first-line" contact with the patient and the provision of those services which are relatively unspecialized and which do not require complex, sophisticated, and expensive programs and facilities. The secondary level of care is provided at selected community institutions, and consist of consultant and diagnostic services. The top level of care involves the super-specialty services, and is provided at regional centers. The specific services to be provided at each level in order to develop an effective and efficient system would be determined by patient needs, resource availability, and economics. University medical centers would probably be the primary base for the specialty services.

Another development which is significant for facilities planning is the implementation of the concept of "progressive patient care." Under this concept there are usually three levels of care, i.e., intensive, intermediate, and self-care. These levels are defined in a manner which indicates the levels of nursing and medical care requirements. It is claimed that the planning of facilities, equipment, and staffing especially for each level of care will result not only in better

care for the patient but also in more productive and economical operations. As a further attempt to match facilities and resources to patient needs, some hospitals are adding facilities for ambulatory patients whose requirements for elaborate and expensive facilities and nursing staff are less. Without these facilities, many such patients are now admitted to expensive hospital nursing units and thereby consume unnecessary resources.

The Federal Government has shifted its emphasis from physiological research to the development of health-care delivery systems in order to implement that knowledge which is already available, and to make health services more available to the entire population. This shift has been reflected through granting agencies as well as programs such as those of the "war-on-poverty." The result has been an increased emphasis within institutions throughout the health field, and especially within university medical centers, on the development, evaluation, and demonstration of new models of health care delivery systems.

Possibly the most important factor affecting many of the changes and trends mentioned herein is cost. There is growing concern over the rapidly rising costs of health care and their possible detrimental impact on the entire health-care system. Largely because of increasing costs, all aspects of the health field are under increasing scrutiny by both governmental and consumer agencies. Several recent investigations of health-care costs have resulted in indictments of the health field as representing a "non-system" which is very low in productivity, and which, in many respects, is too much governed by the narrow financial and political interests of certain factions. The health education

institution and the medical center must, of course, be responsive to these problems.

New methods and equipment are being incorporated in hospitals in attempts to increase productivity. One of the most important of these is electronic data processing and communication systems. Another is automatic equipment in some of the myriad material-handling functions in hospitals. Also, convenience and pre-packaged frozen food systems are being adopted. These and other developments are requiring radical changes in design and operating systems.

Thus, it is seen that the process of planning for clinical education facilities must involve decisions regarding many developments in the health field.

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CHAPTER V

A PLANNING EXPERIENCE

The author served as project engineer in a major facilities planning effort at the Medical College of Georgia during 1967-68. Involvement in this planning project provided most of the insights and information upon which this and subsequent chapters are based; i.e., the planning effort at the MCG was the "experiment" phase of this research. This chapter describes the author's experience in the planning project. Because of the nature of the present investigation, much of what is described herein is in the form of perceived deficiencies and problems relative to the logical structure and order sought in the systems approach and in management science applications. Also, it should be noted that many of these deficiencies and problems derive from environmental characteristics which are by no means unique to the Medical College of Georgia.

In response to increasing needs and pressures within the State of Georgia and the nation for additional physicians, the Medical College of Georgia, during 1965-66, decided to increase its entering class enrollment in Medical School from 100 to 144 students. With the approval of the Regents of the University System of Georgia, the MCG administration began planning for this increased enrollment and for the additional facilities that would be required. The new facilities expected

to be needed were a basic science building and additional clinical facilities, both of which were to be constructed in conjunction with facilities for a new School of Dentistry. The Regents gave preliminary approval for a construction project in the amount of \$5,000,000 which was to include clinical facilities for both Medicine and Dentistry.

In addition to the need for an expansion of enrollment, the Dean and Faculty of the School of Medicine felt an urgent need for other types of changes, including changes in programs, facilities, and image. For example, patients of the Eugene Talmadge Memorial Hospital, the teaching hospital of the MCG, were primarily medically indigent patients, sometimes referred for specialty care but more often for purely economic reasons. It was felt that the patient population should be a more representative cross-section of the population of Georgia, or at least of the surrounding community, including more "carriage trade," outpatients, and emergency cases. The School wanted to develop better and more advanced models of health care delivery systems to be used in education and in providing services to the people of the State. It wanted to incorporate modern management and support systems for more efficient and effective operations. Also, it was attempting to develop a more flexible "multi-track" curriculum for medical students, which might have significant implications for programs and facility requirements.

The Medical School was already involved in a process of major curriculum change at the time the facilities planning project was initiated. Several faculty conferences had been held off-campus for the purpose of developing plans and voting for the basic structure of the

new curriculum. The faculty voted in favor of a new curriculum which was a significant departure from the old one, and it established committees for implementing the decision. The new curriculum was to include more electives, more flexibility to develop individualized programs of study, and new multidisciplinary clerkships.

The Regents and the MCG administration selected an architectural firm from Atlanta to plan and design the clinical facilities. The firm was reputable and successful, and had performed other jobs for the University System of Georgia, but it had little if any experience in designing hospital facilities. The MCG administration apparently was not displeased by this inexperience; indeed it was felt that such a firm would be free of preconceived ideas and opinions and would therefore tend to be more imaginative and creative.

After initial interviews and discussions with top MCG officials, the architect, with participation from the Dean of the School of Medicine, conducted interviews with the chairmen of clinical departments and other key faculty and hospital personnel. These interviews were all conducted during one week in June, 1966. Based upon information from these interviews, the architect developed conceptual plans that included an extensive addition to the existing hospital structure, provision for better integration of inpatient and outpatient services, and the location of services such as to promote a body-organ orientation for medical education.

Discussion of these tentative plans brought out many serious difficulties and questions related to quality improvements, program

conflicts, and cost, and it was decided to attempt a more comprehensive and in-depth approach to planning for the facilities. In addition, since the Dean and the Faculty of the new School of Dentistry had not yet been recruited, it was decided to separate the dentistry and medicine phases of the project so that the School of Medicine could proceed with planning and construction without delay.

At this point the Regents were unaware of the probable cost of the facilities being considered by the MCG. Although the preliminary project approval was for \$5,000,000 for both dentistry and medicine, the cost of facilities being considered by the School of Medicine alone was now estimated to be \$25,000,000. Some indication of the reasons for this ambitious planning, and possibly for the wide discrepancy from the Regents' initial funding, can be obtained from a brief review of the existing hospital structure.

Prior to 1956 the MCG used the University Hospital, a city-county institution, as its teaching hospital. When the College decided that, for the purpose of developing improved teaching programs, it should build and operate its own hospital, a serious conflict and dispute resulted with the University Hospital and local physicians. Although the reasons for the disagreement are difficult to assess fairly and clearly, there are several possibilities. The local physicians who had served on the faculty of the School of Medicine while maintaining a private practice did not appreciate the prospect of losing this relationship. They may have also feared the possible threats to their practice of the new hospital and a full-time faculty. The issue of the

"corporate practice of medicine" was raised, which led to a series of meetings and negotiations with the Richmond County Chapter of the Medical Association of Georgia. The result was a negotiated agreement between the Medical Association of Georgia and the MCG which specified the intended nature of the new hospital and the types of patients it was to serve. Essentially, the new Eugene Talmadge Memorial Hospital (ETMH) was to be for medically indigent patients referred to it for teaching purposes by private-practice physicians and health agencies. The faculty were to serve only patients referred to them, and were not to benefit personally from fees charged the patients. Also, private-practice physicians were not to admit and treat their patients in the ETMH.

As a result of these negotiated operating policies for the ETMH, the image of the hospital and the type of patient clientele seen did not, in the more recent judgment of most of the faculty, provide what was needed for good medical education. Also, the high proportion of indigent patients placed the Hospital in severe financial difficulty. A patient clientele consisting of a more representative cross-section of the population, including more paying patients, would help improve both of these conditions. In order to obtain such patients, it was felt that the Hospital's image, programs, and facilities would have to be improved significantly.

The existing ETMH facility, completed in 1956, was designed for some 850 beds, with relatively few specialized patient-care units. The patient rooms were two- and four-bed rooms. Few baths were provided. While a few examining rooms were provided on each floor and a small

clinic was included on the first floor, accommodations for large outpatient operations were not provided. Only a few offices for the clinical faculty were provided on each floor, no research space was included, and the design did not facilitate the educational process of medical students. The logistical, communication, and other support systems in the facility did not seem to reflect the best engineering available even at the time of the planning of the hospital. Also, the facility was not sufficiently attractive and did not incorporate the features which would be necessary to attract the patient clientele and create the image desired by the School of Medicine.

The Hospital had never operated at more than a 650-bed capacity. In 1968, it was operating at approximately a 400-bed capacity. Many of the patient rooms had been converted to offices, research labs, and special procedure rooms. The outpatient program had expanded into some of the nursing units and into outlying buildings.

Although there are, no doubt, legitimate historical reasons for many of these characteristics of the existing facility, they were considered to be serious deficiencies in relation to present objectives, needs of the educational process, and the state-of-the-art of planning and design for clinical education facilities.

In consideration of the several ambitious objectives of the School, the many deficiencies of the existing facilities, and the recognized complexities and difficulties of the planning process, the Dean of the School of Medicine decided to attempt to develop a multidisciplinary team for a comprehensive, innovative, and in-depth approach to planning the new clinical education facilities.

Initiation of the Systems Planning Project

The architect was given the charge of organizing a team consisting of specialists such as industrial engineers, operations researchers, behavioral scientists, and communications experts. Consultants in each of these fields were located and asked to submit proposals stating their expected contributions, methodologies, costs, etc. The architect then assisted the Dean of the School of Medicine in evaluating these proposals and determining who should comprise the planning and design team.

At the invitation of the architect, the Director of the Hospital Systems Research Group at the Georgia Institute of Technology submitted a preliminary proposal to assist in functional planning and programming through the use of industrial engineering, operations research, and systems analysis and design. Since funds available for planning were not sufficient to form the type of team initially envisioned, and because of an apparent strong need for the type of work proposed by the Georgia Tech Group, it was decided to begin the planning with a team consisting of the architect, industrial engineers, and members of the MCG staff.

These activities and decisions resulted in a formal proposal entitled "A Proposal for Operational Research and Planning for the Clinical Services Building, Medical College of Georgia," which was submitted to the President of the MCG in November, 1966. The general objective of the proposed project (later identified as the "Systems Planning Project") was to develop a set of industrial engineering specifications for the academic and hospital systems which would be involved

in the pursuit of approved goals of the relevant subdivisions of the MCG and which would serve as a basis for the architect's design for the new Clinical Services Building. Specific objectives were as follows:

1. To ascertain overall goals and constraints relevant to the expansion program of the MCG.
2. To ascertain the specific goals and functional requirements of each relevant subdivision of the MCG, due regard being given probable future trends in medical and dental education.
3. To identify the clinical resources required for medical and dental education and research, and to determine the interrelationships among the academic and hospital systems to be accommodated by the new construction.
4. To develop a set of system specifications for use by the architect in designing physical facilities which would effectively promote the educational and research goals of the Medical College of Georgia.

A procedure involving 13 major steps was proposed for satisfying the objectives of the Systems Planning Project, as follows:

- A. Conduct a series of interviews with the President, the Deans, members of the Committees on Medical Education and Clinical Research, and the Hospital Administrator in order to ascertain overall goals and constraints, including particularly the extent to which new and different concepts and methods of education are to be adopted, the nature of organizational changes (if any), and policy limitations in respect to students, faculty, funds, time, and other relevant factors. Enumerate

these goals and constraints, and obtain approval from the Dean.

B. Conduct structured interviews with individual department chairmen and with selected educators and researchers in order to ascertain specific goals of each department, major laboratory, and subdivisions thereof, and to ascertain *functional* requirements for implementing such goals. Augment interviews by questionnaires and by analyses of relevant reports and records. Enumerate and describe the functional requirements resulting from this survey.

C. Analyze the specific goals and functional requirements obtained in Step B, and identify instances in which stated goals or requirements conflict with each other or with the overall goals enumerated in Step A. Refer such conflicts to appropriate officials for reconciliation, and revise functional requirements as necessary. Submit the revised version to the Dean for approval.

D. Conceptualize the major academic systems that will be required for performing the educational and research functions approved in Step C. As entities conceptualized to include all resources necessary for achieving the specific goals identified from Step C, these systems will describe the inputs, outputs, and internal relationships involved in medical teaching and medical research. This step will result in flow diagrams which depict each academic system and the interrelationships among academic systems, together with the general attributes of all such systems.

E. Based upon the requirements for clinical resources, identified as a part of Step D, confer with the Dean and the Hospital Administrator on hospital operating policies. Then, conduct a series of

structured interviews with members of the hospital management team and with selected hospital department heads and supervisors in order to ascertain the functional requirements of each hospital department or area. Analyze these functions, identify conflicts, and refer results to the Hospital Administrator for reconciliation of conflicts and approval of hospital functions.

F. Conceptualize the major hospital systems that will be required for performing the hospital functions approved in Step E. This will result in flow diagrams and general attributes of all major systems of this teaching facility.

G. Consolidate the results of Steps D and F in order to obtain a comprehensive set of flow diagrams and attributes for both academic and hospital systems. Gather gross input and output data from existing systems, and synthesize such data for new systems not presently existing but required in the proposed plan. Compile an outline which includes, for each system, an identifying title, a statement of function, and interval estimates of space and personnel requirements. Submit this outline to the Dean.

The completion of Step G would enable the architect to develop a Program of Requirements for the Clinical Services Building. Concurrent with this architectural work, the remaining three steps in the proposed project would be undertaken.

H. Establish priorities for the conduct of detailed studies of individual systems and system interrelationships. Criteria inherent in

the "systems approach" of modern industrial engineering practice will be combined with medical values deduced from the results of Steps A and B as bases for the priorities. Submit recommended priorities to the Dean for modification and approval.

I. Conduct industrial engineering studies of individual systems. The comprehensiveness and intensity of each study will depend upon its priority as established in Step H. Such studies, utilizing whatever methods and techniques are appropriate in each instance, are expected to involve both systems analysis and systems synthesis, with emphasis upon quantitative and qualitative system attributes with architectural implications. Maintain a close working relationship with the architect, and supply him with interim results from individual studies as they become available. Independent critiques from hospital industrial engineers with specialized experiences will be obtained and visits to other institutions will be made where appropriate.

J. Summarize findings from Step I. Refine the interval estimates of Step G, and establish general specifications for the configurations, relative locations, and special features of space allotments for each system. Even though the results from this Step will be useful in the installation of systems after occupancy, the principal emphasis will be upon system specifications needed by the architect. Submit these industrial engineering specifications to the architect and to the Dean. The completion of Step J would satisfy the objectives of the proposed project and would enable the architect to proceed with the development of architectural drawings and specifications of the Clinical Services Building.

The Director of Georgia Tech's HSRG was proposed as Director of the Systems Planning Project. In addition, it was proposed that the equivalent of three full-time persons from the HSRG be assigned to the project: one graduate engineer splitting his time appropriately between Augusta and Atlanta; an IE graduate student to be stationed in Augusta during each academic quarter; and another equivalent full-time engineer stationed in Atlanta, making trips to Augusta when necessary. The proposed time schedule for the project, shown in Figure 1, projected a project period of 18 months.

During the discussion of this proposal it was decided that, since the HSRG and the MCG were both part of the University System of Georgia, the engineers could be assigned to project work at the MCG without making payments through the architect's subsidiary consulting firm, Heery Associates, Inc., which would be used as a financial mechanism for the project. Therefore, the formal contract with Heery Associates, Inc. included only the services of the architects and special consultants. All other costs were borne directly by the Medical College and by Georgia Tech. It was further decided that the principal project engineer (the author of this paper) and the graduate student should be stationed full-time on the MCG campus in Augusta. The Systems Planning Project was approved by the presidents of the two sister institutions and was activated January 1, 1967.

Definition of Goals and Constraints

As indicated previously, Step A was to ascertain the overall goals and constraints relevant to the expansion program of the MCG.

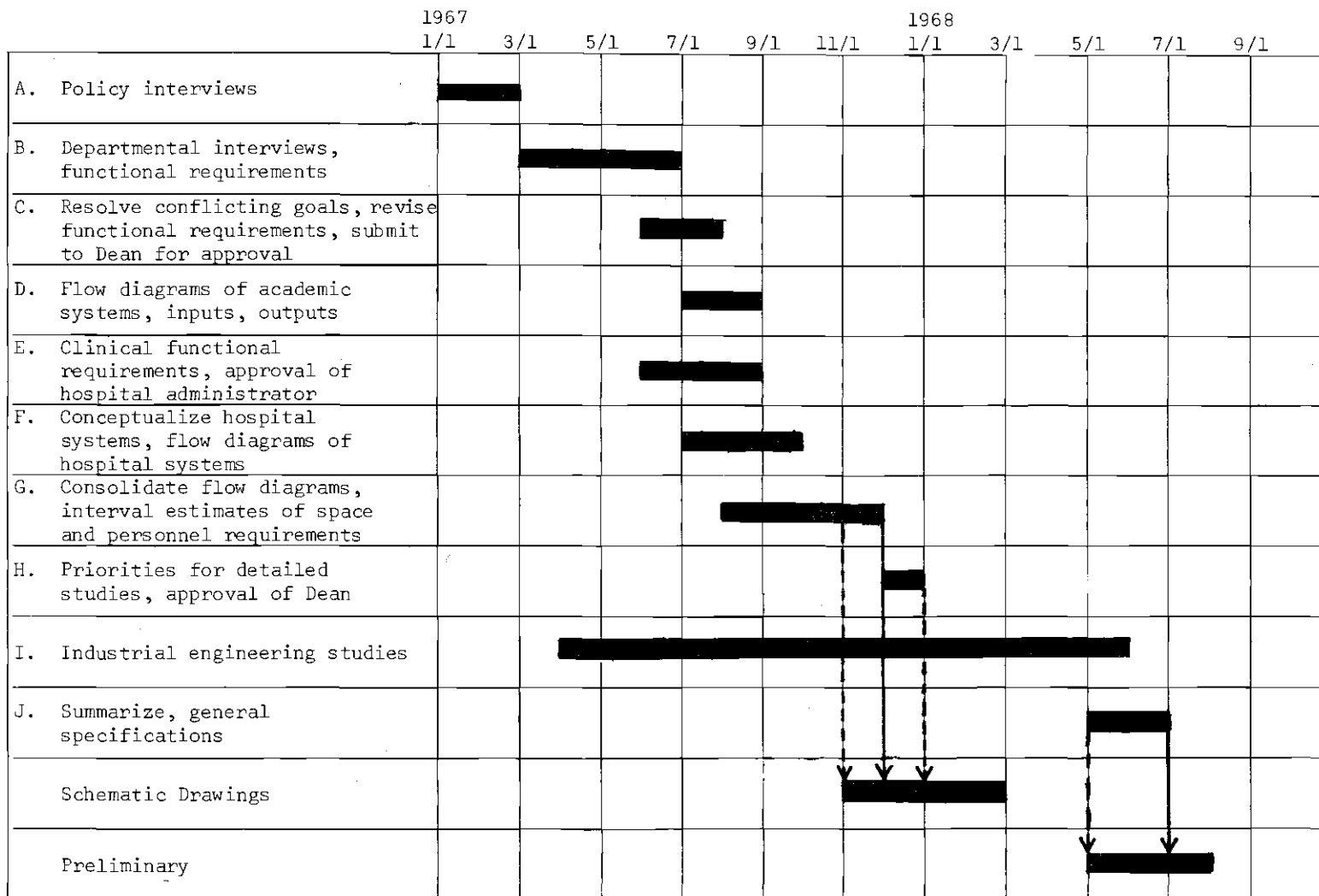


Figure 1. Schedule of Proposed Steps for Systems Planning Project

This was accomplished through interviews with top administrative and faculty personnel, a review of audio-tapes of previous meetings and interviews, and a review of relevant documents and records. Findings were summarized, submitted to appropriate officials for approval, and distributed to the Faculty of the School of Medicine as a basis for further and more specific and detailed planning.

Step B was to ascertain the specific goals and functional requirements of each relevant subdivision of the MCG. This was accomplished primarily through the chairmen of clinical departments. In developing an approach to the accomplishment of this step, it was decided that there were at least two major aspects of the planning process for the Clinical Services Building. One aspect was the improvement of the quality of clinical education, research, and service programs. The other was an increase in the magnitude of operations caused by the increase in the number of medical students to be admitted.

In order to develop systematically the information and ideas related to these two major aspects of the planning process, as well as the necessary basic information related to departmental programs, personnel, and facilities, Step B was conducted in the following parts:

Part 1: Current Description of the Departments--Department chairmen were asked to furnish certain descriptions and items of information regarding existing departmental programs, personnel, and facilities. These descriptions and items of information were to help develop a complete picture of each department and thus help to avoid omissions in the planning process. They

were also to provide some base points from which projections could be made, and would facilitate the integration of the present structure into plans for the new structure.

Part 2: Quality Improvements--Department chairmen were asked to describe their plans for improving the quality of clinical education, service, and research programs of their departments. These descriptions were to be in sufficient detail to reveal specific and implied functional requirements.

Part 3: Increased Enrollment--Department chairmen were asked to describe the expected effects of the increase in the medical student enrollment on their departments' functional requirements, assuming that the quality improvements of Part 2 were implemented.

Part 4: Interviews--Each of the clinical department chairmen were interviewed. The interviews covered the major points resulting from Parts 1, 2, and 3, with major emphasis on points requiring explanation, amplification, etc., and on points seemingly omitted.

The development of information regarding plans was separated into the two aforementioned major aspects (Parts 2 and 3) for several reasons. First, it was felt that the departmental chairmen would find it easier to consider necessary and desired changes for quality improvements separate from those for increased enrollment. Also, it was assumed that the separation of these two types of information would enhance evaluation and decision making later in the planning process. It was

anticipated that monetary constraints would force trade-offs between these two types of changes, i.e., quality and quantity. The nature of these trade-offs is shown conceptually in Figure 2.

With reference to Figure 2, the

. . . planning objective is to move from the present state (origin of the diagram) to some future state where both quality and magnitude are increased, but of necessity, within the domain bounded by the new monetary constraint of the future state, CC. Psychologically, it may be advisable, in the interests of allaying pent-up dissatisfactions with the level of q_0 , to seek quality improvements first. But, if movement up the q-axis extends to, say, q_3 , it will be noted that the monetary constraint would permit a magnitude of only 132 students. (Similarly, 156 students could be admitted if a new quality level of q_1 is acceptable.) But, in order to satisfy the requirements (144 students and a cost constraint at line CC), a quality level of q_2 must be held (see point S).

The aforementioned relationships implicitly assume a particular future-state system. It will be noted that the axes of the diagram are components of system *outputs* and that the constraint line is the system *input*, but it may not be so obvious that the positioning of the line in relation to the axes, at a given cost, is determined by system *productivity*, a function of system *design*. At a given productivity (corresponding to line CC), trade-offs such as those cited above are inevitable, and improvements in any of the factors (quality, magnitude, or cost) can be achieved only at the expense of one or more of the other factors. But, if productivity could be increased, a new constraint line, C^1C^1 , would result, making possible more favorable relationships among quality, magnitude, and cost. For example, 144 students could be educated at quality level q^1 , without spending more money than the original constraint of the future state. (Note: the shift from CC to C^1C^1 is the result of higher productivity, not more funds.) Such improvements in productivity are realized by better systems designs.¹

¹Smalley, Harold E., "A Planning Methodology for a Teaching Hospital," (Application for Research Grant, U.S.P.H.S., Unpublished), Program in Hospital and Medical Systems, Georgia Institute of Technology, Atlanta, Georgia, 1969, p. 24.

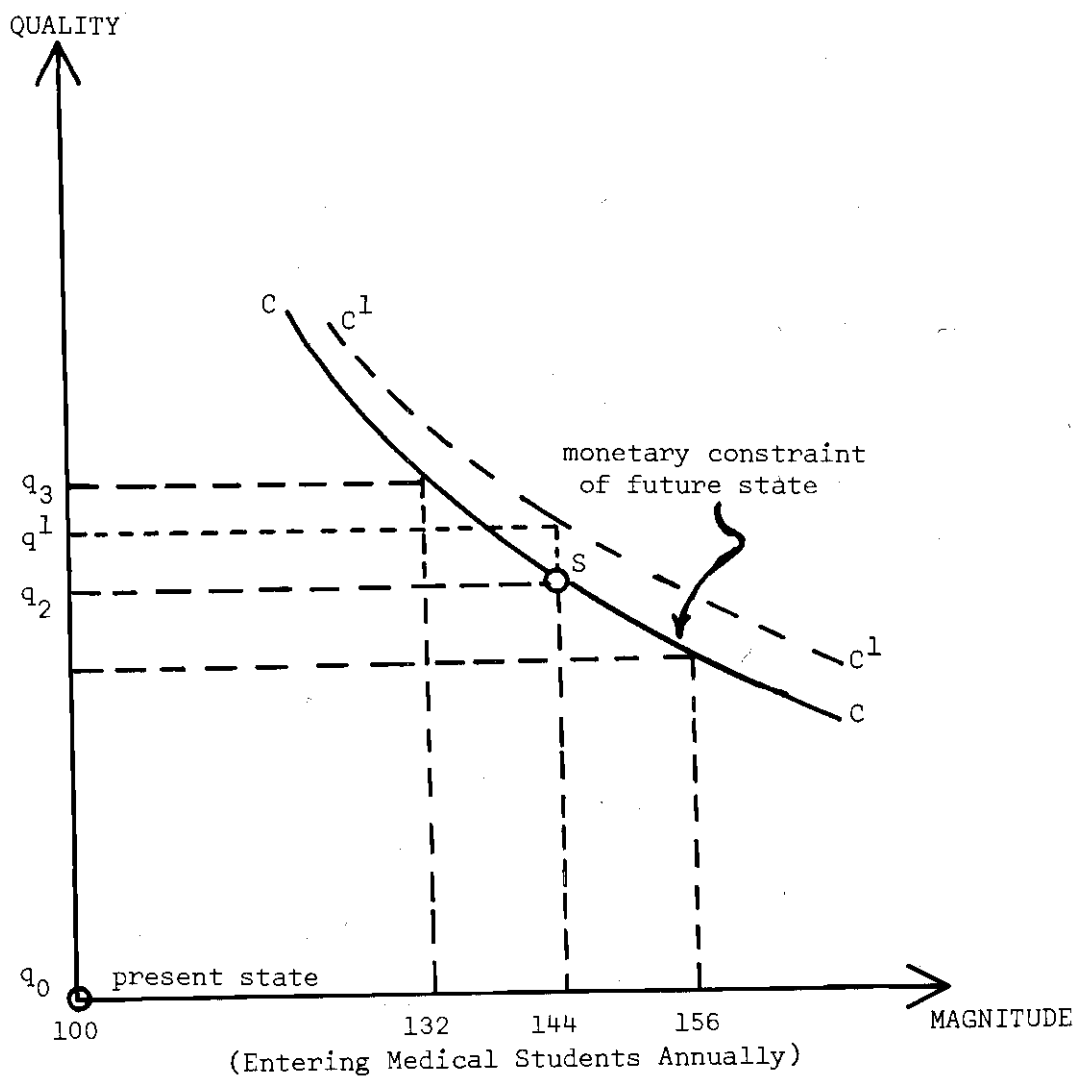


Figure 2. Quality-Quantity Tradeoffs in Planning²

²*Ibid.*, 24a.

Results of Interviews

Step A was performed during January, February, and March 1967 by the Project Engineer, supported by his team of staff members and consultants. A report was submitted to the Dean, who subsequently distributed it to the faculty during the latter part of April. The following is an outline of the elements of the report:

A. Primary Goals

1. Education
2. Research
3. Health-care delivery models
4. Service

B. Policies Related to Secondary Goals

1. Enrollment
 - a. Numbers of students
 - b. Residents to support student programs
 - c. Change in internships
2. Faculty
 - a. Dependent upon student programs
 - b. Class size
 - c. Involvement in teaching, research, and service
3. Medical School Curriculum
 - a. Flexibility
 - b. Free and elective time
 - c. Team practice
 - d. Twelve-month schedule
 - e. Increased emphasis on primary health care
 - f. Decreased emphasis on specialties during undergraduate years
 - g. Residency training involving regional hospitals
 - h. Major emphasis on medical students
4. Patient Population
 - a. All socio-economic groups and representative disease patterns
 - b. General outpatient and emergency programs
 - c. Anticipate no non-paying patients in future
 - d. Increase in direct referrals to physicians
 - e. Health care for staff, students, and dependents

5. New Models of Methods for Providing Health Care
 - a. Demonstration projects
 - b. Broad concept of rehabilitation
 - c. Graduated care
6. Research
 - a. Expansion and improvement
 - b. Increase in student research
7. Clinical Service Facilities
 - a. Expansion and improvement
 - b. Student offices and laboratories
 - c. Maintain dignity of the individual
 - d. Guard against depersonalization

C. Decisions Made (Constraints)

1. Locations of buildings fixed
2. Facilities to be justified on the basis of 144 medical school entering class
3. Use of present research space
4. Use of the teaching-clinical unit concept
5. Maintain present organizational structure
6. Relationship with dental facilities
7. Contents of new basic science building

D. Projections and Assumptions

1. Student attrition rate
2. Use of clinical facilities by allied health students
3. Increased emphasis on ambulant, outpatient, and nursing-home care
4. Diminishing distinctions between private and staff patients
5. Flexibility in clinical curriculum
6. Need for fringe benefits
7. Increased in-service training programs
8. Increased use of volunteers
9. Increased use of industrial engineering services
10. Additional affiliations with local hospitals
11. Changes in continuing education
12. Student involvement in non-hospital practice

E. Generally Accepted Concepts

1. Long waiting lines and large groupings of patients should be avoided
2. Integrated inpatient and outpatient services and educational programs
3. Functional interrelationships should strongly influence relative locations within facilities

4. Organs or disease processes should serve as focal points for facility organization
5. The clinical education hierarchy will remain unchanged
6. Criteria for patient admissions
7. Student examining rooms should be provided
8. Student clinical labs should be provided

F. Suggestions and Ideas

1. Separate patients in diagnostic processes from those under treatment
2. House ambulatory patients in separate facilities
3. Provide a general admission area and procedure wherein patients would receive a comprehensive evaluation
4. Relate intensive care areas so that personnel and equipment can be shared
5. Develop a coordinated communication system
6. Automate hospital admission procedures
7. Automate certain steps of physical examinations

Step B was performed during the period from April to September of 1967, and a summary report was submitted to the Dean in September. The following is an outline of the elements of the report:

- A. The number of students and faculty planned for ETMH
- B. Student lab work
- C. Student offices
- D. New residency programs
- E. Dental student involvement
- F. Allied health student involvement
- G. General outpatient services
- H. Emergency program
- I. In-Service training
- J. Areas of common interest
- K. General admission area
- L. New specialty areas, programs, and changes in present programs
- M. Outpatient programs
- N. Patient mix and management
- O. Rehabilitation
- P. Housing for ambulatory patients
- Q. Intensive care
- R. Research
- S. Facilities
- T. Contingencies

Because of the general nature of the information obtained and the plans described, the relative autonomy of the academic clinical departments, and the lack of specified monetary constraints, there were no manifested conflicts in goals at this point.

The report to the Dean also suggested possible areas for further studies by the SPP team. Discussions with the Dean were requested in order to establish priorities for further studies and to make arrangements for their accomplishment. The suggested areas for study included the following:

- A. Areas of common interest (systems orientation design)
- B. Flexibility
- C. Decentralized versus centralized facilities
- D. Facilities for ambulatory patients
- E. Flows
- F. Information and data processing systems
- G. Instructional facilities
- H. Lengths of stay
- I. Student elective process
- J. In-house versus contract services

The Dean was also requested to furnish assistance in determining the probable size and organization of future academic clinical departments and clinical services and in providing arrangements for developing the program of requirements. Also, some indication of the future of research programs was needed.

In addition to the accomplishment of Steps A and B, the following projects were undertaken during the period from April to September of 1967 by the SPP team (approximately nine man-months of effort).

1. A study of outpatient clinics to develop information such as the following:
 - Identification and description of clinics
 - Flows, where appropriate
 - Supporting service requirements

- General staffing arrangements
 - Special equipment and facilities required
 - Present clinic size
 - Projected future size
 - Projected facility requirements
 - Time and schedule requirements
 - Ideas for improvement and facility design
2. Preliminary phases of Step E, as follows:
- Getting oriented and gaining familiarity with the area
 - Describing functions, interactions, etc.
 - Describing present facilities
 - Obtaining ideas for improvements from interviews, literature, etc.
 - Determining how to project future needs
3. The description of major flow-processes, such as the following:
- Laundry
 - Patients
 - Food
 - Trash
 - Drugs
 - Central Supplies
 - General Supplies
 - X-rays
 - Specimens
 - Medical Records

Observations on First Phases of Planning

In general, the procedural and structural aspects of the methodologies for Steps A and B were accomplished without unexpected difficulty. Also, most of the administrators and faculty contacted were willing to give their time and effort for interviews and report writing, were sympathetic with the objectives of the planning project, and were progressive and capable representatives of their functions and disciplines. In spite of these favorable conditions, numerous difficulties and deficiencies became apparent during Steps A and B. Many of these were due to factors common to most university medical centers; others

were due to local conditions. A large number of the difficulties and deficiencies seemed to stem from a general lack of understanding and know-how by MCG Faculty and Administration regarding a facility planning process of this type and size, including the need to integrate it with a long-range managerial planning process for the institution. Some of these difficulties and deficiencies will be summarized in the following paragraphs.

On several significant issues there was apparent confusion among administrative officials and planners regarding the levels at which planning decisions and action should take place. Consequently there was a lack of completeness and specificity in stated objectives and plans related to subjects such as funding, timing, affiliations, organization structure, operations, and curricula. In many cases there was a lack of real planning at the departmental level. Some departmental chairmen considered the institutional framework for planning, i.e., objectives, assumptions, constraints, etc., inadequate for an effective process. Others did not have the inclination, time, or know-how for long-range planning.

There was no strong follow-through and leadership from the Dean and other key officials on gaining acceptance for proposals such as organ specialization in the arrangement of clinical units and the development of the clinical teaching module. These ideas were left unsupported for the departmental chairmen to interpret for themselves, change, reject, accept, or ignore.

It was clear that the projections and plans of the clinical departments were not derived from and did not reflect a general and

comprehensive managerial plan for the School of Medicine or for the Medical College. These projections and plans were not integrated and coordinated, and when put together did not provide a program designed to accomplish a set of common objectives. One example of this deficiency involves the curriculum; many departments had little idea how many students they would have and in what ways they would relate to other departments in the teaching programs. There was also little coordinated and integrated planning with the allied health schools, whose students would take training in the clinical facilities and be involved in the proposed "team practice" learning situations.

Although the departmental chairmen were instructed to base program planning primarily on the requirements for teaching 144 medical students, several other factors were as important to the departments in their planning as was the expected number of medical students. Some of these factors were as follows:

1. The requirements for an approved residency program.
2. The need to maintain the professional proficiency of the staff.
3. The needs of the community.
4. The influence of external (primarily federal) funding.
5. Research.
6. Requirements for attracting and keeping professional staff.
7. The need for a certain cross-section of patients and cases.
8. The establishment of "centers of excellence."

During the Step B process it appeared that residents, research, and special faculty interests were of major importance. The lack of

specified institutional objectives regarding residency training was of special difficulty in attempting to coordinate departmental plans.

In some cases the stated objectives and plans appeared to be a direct function of the personalities of personnel filling the key positions. Since there was no objective way of determining what was "right" or "best," their judgment in developing facility plans was essential in spite of their bias. This seems to be a serious difficulty in this type of long-range planning process. Facilities designed to suit a particular individual may not be what the next person filling that position feels is needed; and turnover is relatively high.

Several opposing forces operate among the departmental chairmen of the School of Medicine. The clinical services and clinical academic programs are strongly interdependent and must be interdigitated for effective and efficient functioning. This results in a force towards close collaboration among the departments. On the other hand, the departments must exercise a certain degree of autonomy and independence in order to maintain the integrity of their academic and professional disciplines as well as their "academic freedom." The resolution of these opposing forces is a complex aspect of the planning process, and tends to involve destructive competition and political maneuvering among the departments and between them and administration.

In spite of the need for strong central leadership and coordination, there often appeared to be too little confidence in the ability and willingness of administration to support and respond to departmental planning. This was probably due to many of the problems mentioned above

as well as to the difficult and uncertain role of administration in most academic institutions.

While there was a general willingness among departmental personnel to work with staff planners on matters related to their departments, there was significant resistance to any meaningful effort towards inter-departmental planning and coordination which might require compromises. There appeared to be a similar hesitation among administrators to extend themselves beyond normal day-to-day operating patterns in order to obtain the coordination, approvals, and commitments required from both their own internal organizational units and external agencies for definitive planning.

Many of the planning meetings degenerated into discussions of existing operational problems. There may have been several reasons for this. First, current problems are usually uppermost in the minds of personnel who are operating programs, and these problems are easier to discuss and to solve. Most personnel are more accustomed to and comfortable with handling current operational problems than long-range planning problems. Also, some of the departmental personnel seemed to feel that the staff planners provided a channel through which they could register current problems and dissatisfactions with top level administration when other channels seemed to fail.

The development of departmental reports for Step B required considerable time and effort. It became apparent that comprehensive top-level managerial and institutional planning upon which facilities planning could be based did not exist. Consequently, the time allowed for

the performance of each part of Step B by departmental chairmen (approximately two weeks) proved to be inadequate. Probably as a result of the inadequate time allowed, the departmental reports, with a few notable exceptions, were of poor form and quality. They were difficult to interpret and evaluate, and collectively did not represent an integrated plan for the school.

Response to Report

A summary Step B report was prepared by the Project Engineer and submitted to the Dean in September 1967. The Administration apparently did not review and evaluate this report critically and comprehensively. There was little feedback to the departments and SPP staff even on critical points such as philosophy and concept; numbers of students, residents, and faculty; and sizes of clinical services. The summary report was not circulated to the departments for review. The questions raised by the report, such as those implied under the sections on contingencies and planning considerations, remained unanswered. The SPP staff were left to develop their own approach and organizational arrangements for functional programming, and to set their own priorities on systems studies.

Development of Rough Space Program

By the time Step B was completed it was apparent to the SPP staff that, with the prevailing conditions of administrative and program planning as described above, they did not have the time and resources sufficient to develop detailed and comprehensive sets of flow diagrams of all

academic, clinical, and hospital systems within the established time schedule. It was decided that the time schedule should be met, and that the staff should proceed with the development of a preliminary space program and conceptual drawings based upon those flow diagrams which had been developed, departmental estimates of numbers of personnel, patients, and students, and other information obtained from the literature on hospital and medical school planning. Approximate space requirements for the clinical departments were developed on the basis of detailed estimates of staff, students, and patients. Using guidelines from hospital planning literature modified somewhat to suit local conditions, estimates were then made of the hospital supporting service space requirements. These were then combined into estimates of requirements for new facilities under alternative assumptions regarding the use of existing facilities. A summary report of these estimated space requirements was submitted to the architect.

If time had allowed, the completion of flow diagrams and attributes for hospital and academic systems would have provided several benefits. They would have reflected the nature of academic programs in terms of the flow of students and its implication for facility resources. They would have served as a means for developing and describing major operational systems designs. They would have provided an efficient framework for communication on many planning matters among the architect, SPP staff, and MCG personnel.

Development of Schematic Drawings and Cost Estimates

Based upon the information from Steps A and B and the preliminary space program described above, the architect developed a conceptual and schematic plan for the new and renovated clinical service facilities. The plan called for new facilities to be attached to and integrated with the existing ETMH. The new facilities were in front of the old, thereby creating an entirely new and different appearance. All intermediate-care nursing units were in the new facilities. In addition to providing functional improvements, this was expected to have facilitated the creation of a new image for the institution, which was one of the main objectives. The existing hospital facilities were to be used for research, special patient-care labs, intensive care, and supporting services.

The nursing unit floors of the new hospital were of a "race track" design; patient rooms were on the perimeter surrounding a central core consisting of student and faculty offices, teaching space, administration, outpatient space, nursing offices, and small labs. This central core incorporated most essential aspects of the "clinical teaching unit" concept. It also provided for a close integration of inpatient and outpatient programs. The large floors, containing 80-90 beds, facilitated the organization and location of services around certain focal points involving body organs, systems, or disease processes. They also facilitated a flexible and changeable allocation of beds among clinical services. The estimated total cost of this plan was approximately \$70 million, including a large parking deck and ambulant care facility.

Several major questions arose from reviews of this plan by MCG Administration, SPP staff, and consultants. Among the first of these was the question of cost. With a second analysis and several changes, the architect was able to reduce his estimate to approximately \$60 million. Another cause for concern was the location of the outpatient clinics within the central core. This arrangement would make expansion and change in this increasingly important aspect of medical center operations extremely difficult. Also, there was significant dissatisfaction among several departments with the standardized design for all nursing units. These departments, for example Ob-Gyn and Pediatrics, felt that a more specialized design was imperative for good patient care and teaching. This plan came to be called the "professors' dream," with the implication that the design was oriented primarily toward faculty needs, desires, and convenience.

The President and the Dean eventually decided to reject this facility plan and design, the primary reason being their expected inability to obtain \$60 million for a single-phased (or near single-phased) construction program. It was decided to develop a multi-phased plan, with each phase being identified in concept and content with probable funding sources, e.g., the various federal agencies which fund this type of construction.

Observations on the Development of
the Space Program and Conceptual Plans

The following paragraphs summarize some of the conditions which existed and observations made during this phase of the planning process.

The experience of attempting to develop space estimates and facility plans and designs emphasized the importance of some of the unanswered long-range planning questions. For example, the question of affiliations with the University Hospital (a large city-county hospital adjacent to the MCG campus) and the VA Hospital seemed especially significant. The difference between strong and weak affiliations was directly translatable into a significant amount of facilities and, consequently, construction and operating costs for several departments. In fact, a few of the departments could have conducted large portions of their teaching programs in these institutions under strong affiliations.

This phase of the process also brought out the effects of the inability to state objectives in specific terms and to provide quantitative or objective criteria related to the achievement of these objectives. Without clear objectives and criteria, the SPP staff were limited in what they could do without the direct and extensive involvement of the professional and administrative personnel. Under these conditions, the professional and administrative personnel often had to be involved in even the low levels and detailed aspects of planning. Experience showed that very little could be effectively delegated to the staff planners.

The several conditions described above were compounded by the fact that the departmental chairmen were not able (or willing) to resolve several important issues among themselves. For example, there was disagreement over whether clinical laboratories should be centralized or decentralized. The clinical chairmen were not willing to accept the judgment of the Department of Pathology; they were not able to resolve

the issue among themselves; attempts to agree upon an outside consultant to help resolve the issue failed; they were not willing or able to state objectives and criteria so that the problem could be studied analytically and objectively; and administration did not settle the issue. In developing the space program and conceptual plans, the staff planners and architect had to make their own assumptions and judgments regarding this question.

For several reasons, some stemming from characteristics inherent in schools of medicine and academic institutions, and others involving local conditions and personalities, administration did not provide strong leadership and coordination during these phases of the planning process. This may have been largely due to the Dean's and President's lack of time, and to the fact that they had no one to whom to delegate this responsibility who had direct knowledge of and influence over the major organizational elements involved. While hospital administration probably came closest to meeting the requirements for providing planning project management, it either would not or could not fill this role at the time.

Another effect of the "thin" administrative structure was that there were too few people to do the general programming, i.e., the development of general planning information, including the description of planned future programs, in sufficient detail for facilities planning and design. As a result the SPP staff and departmental chairmen had to spend much of their time in general programming activity. This was wasteful of talent and resources which could and should have been devoted to other important aspects of the planning process.

No formal organizational arrangements or assignments for planning were made within the institution. This left the SPP staff with the condition of having to make extensive contacts throughout the institution and to serve as a focal point for all information related to the clinical service facilities through whatever informal arrangements they could establish. This not only proved to be impossible with the planning staff available, it was also ineffective as an approach to the facilities planning process. A specific example of organizational deficiencies was the lack of a direct formal relationship between the SPP staff and the vice president in charge of campus planning. An example of the results of these organizational deficiencies is that the SPP staff did not learn except by accident that the MCG was to furnish certain services for a new Georgia War Veterans Nursing Home, which would have a significant impact on supporting service workload. The SPP staff did not have effective and efficient communication and information channels linking them with institutional administrative planning.

Since the systems engineers were the only full-time staff planners, and since no other formal organizational arrangements or assignments were made for planning, many people began to view the systems engineers as "the planners" and assumed that they were serving as staff planners for all major aspects of the planning process. This led to much confusion and misdirected effort, and resulted in the systems engineers' having little opportunity to do systems analysis, systems planning, or systems design. It probably also gave certain other personnel an excuse for not doing what they could do and should have done as a part of the planning effort.

The magnitude and requirements of the job of functional programming were grossly underestimated both by MCG Administration and by the SPP staff. In order to provide a basis for facilities planning and design, the functional program should consist of decisions and projections regarding staff, students, patients, policies, procedures, systems, organization, etc. (A detailed listing of elements which should be in a functional program is shown on pp. 178-180.) None of this information was readily available. Much effort was required to develop even the roughest form of information in these areas. Very little useful operational information was available even on present operations. Present operating policies and procedures were not standardized or documented. The authorities and responsibilities for developing and approving such policies and procedures for the future were unclear. Because of conditions such as these, large amounts of general staff work and general managerial planning were needed in order to do a satisfactory job of functional programming.

Because of several characteristics of the planning process described above, few industrial and systems engineering studies and designs were accomplished up to this point. It appeared, however, that the results of these phases of planning would have been relatively insensitive to any detailed operational and systems planning which might have been performed. The architectural and general planning process was of such gross and unprecise form that expected variations and inaccuracies in the top-level planning and design variables would "wash out" any anticipated benefits of precise and detailed operational and systems planning. Of course, operational and systems planning must be done as

a part of the planning process, but the point here is that their impact on the planning phases up through the initial space program and conceptual design will probably be small.

In addition to functional programming, the systems engineers were also able to provide some assistance in these early phases of the planning process by developing certain types of information for decision making through the use of management science approaches, developing project management networks, and by assisting in making judgments regarding present and future operations and operational systems.

There were, of course, a seemingly infinite number of problems involved in the planning and design process to which industrial and systems engineering approaches and techniques could have been applied. In the face of such a large number of these technical planning and design problems, however, and in view of the many difficulties regarding the general planning arrangements, approach, and methodology, it was difficult to justify the allocation of a significant amount of available planning resources, including systems engineers, to any one or a few of these technical (operational) problems at this time. The needs of the general, overall planning process seemed more significant and compelling.

Even when the timing and needs were appropriate, an original operational systems analysis or systems design was difficult to accomplish within the framework of the planning process. One reason was that the planning decision involved had to be based upon all significant aspects of the problem. Most of the problems for which operational systems analysis or systems design was considered appropriate were of such complexity and involved so many variables that extensive engineering

study over a long period of time would have been required to evaluate all significant aspects of the problem. The research approach, wherein one group may look at one limited aspect of the problem, assuming that over time and in combination with the work of other groups the limited study will provide a worthwhile contribution, is extremely difficult to justify and rationalize within the framework of a particular institution's planning process. In most cases what is needed is the capability to accumulate the available knowledge, information, results, and opinions regarding the problem being considered and to make an intelligent decision with a minimum of specialized and detailed research at the planning institution.

As an example of the type of problem referred to above, the planning and design of a nursing unit would include the following elements:

- nursing organization
- size, in terms of patients and staff
- layout
- location in old or new facilities
- equipment
- distribution systems
- patient mix
- length of patient stay
- centralized vs. decentralized services
- room design; e.g., single- or multiple-bed rooms
- progressive patient care
- the teaching function; space and design implications
- communication systems
- proximity to other areas
- operational systems and procedures

It should be apparent that not all of these elements can be researched and optimized by the planning team. The problem is, of course, one of design and requires a great deal of judgment and creativity.

Critique of Planning Arrangements
and Recommendations for Improvement

Upon the rejection of the single-phased master plan for facilities the SPP staff felt that it was necessary and timely to discuss with the Dean many of the conditions and problems described above so that improvements could be made. After several meetings on these subjects the Dean referred the matter to the President. Subsequent to discussions with the President, the Project Engineer documented and formalized in a memorandum the points covered. This led eventually to a series of three meetings with the MCG Executive Committee in which the Project Engineer and the architect discussed the work that had been done, problems encountered, needed improvements in planning approach and arrangements, and suggestions regarding the future work of the staff and consultant planners. The needs for a better organization for planning, a full-time project manager, a larger and multi-disciplinary planning staff, and more timely and definitive decision making were stressed.

Subsequent to these and other discussions, the President appointed the Hospital Administrator as Project Manager for planning the clinical service facilities. The Hospital Administrator was instructed to make any necessary adjustments in his own staff in order to have time for the planning project, but he continued as Hospital Administrator, and thus was only part-time on both of these demanding jobs. An Assistant Dean of the School of Medicine was appointed as Medical Coordinator for the planning project, and was to handle those aspects of planning which involved decisions on medical and academic matters. In addition, the Project Manager was to form planning committees as he deemed necessary.

These meetings, discussions and decisions occurred in March and April, 1968.

Summary of Latter Phases of Planning

The Project Engineer worked with the Project Manager during the first weeks after the latter's appointment in developing proposed organizational arrangements and project management networks. Only a part of the proposed organization structure (shown on p. 225) was implemented. The hospital supporting services sub-committee was formed and began functioning. The chairmen of clinical departments formed their own planning committee and subcommittees, but they never became operational.

The Dean of the School of Medicine resigned effective July 1, 1968, and the President became Acting Dean until a replacement was found.

During the late spring and summer of 1968 the Project Manager, staff planners, and personnel representing clinical departments and the hospital met with the President to develop a new master plan for clinical service facilities and to identify and sequence its various phases. A multi-phase master plan was eventually selected which consisted of the following elements to be constructed in approximately the sequence shown:

- Office and clinic building
- Hospital addition for supporting services
- Women and children hospital
- General medical and surgical hospital
- Psychiatry and rehabilitation facilities
- Parking deck and ambulant care facility combined

At the time of this planning the prospects of obtaining construction funds from the Federal Government within two or three years were

felt to be negligible. It was decided not to wait on matching funds from the Federal Government but to spend the approximately \$5 million available from the State on the most urgently needed and feasible type of facility. Because of these considerations, and because of a strong feeling that the Medical College should expand and strengthen its outpatient programs, an office and clinic building was selected as the first phase of the plan.

The planning organization failed to function and to develop specific and detailed plans for several months after the decision to build an office and clinic building. In an attempt to promote some meaningful planning, during September 1968 the SPP staff developed a tentative space program for the building, based upon information obtained in Step B, to assist the architect in developing a design concept and gross cost estimate. Copies were submitted to the Project Manager and the architect. In addition to formulating a basic design concept and cost estimate, the architect developed schematic drawings on the basis of the tentative space program, also in hopes that this "test" plan would aid in motivating more active, timely, and definitive planning within the MCG in the development of a functional program for the building. However, no significant action was taken regarding these plans during the fall of 1968. For example, the plans were not presented to or discussed with the departmental chairmen.

During November, a physician and member of the faculty in charge of one of the major clinics began meeting with the Hospital Supporting Services Committee to discuss arrangements for his clinic. He became disturbed with many aspects of the plan as well as the planning process,

and especially with the facts that the clinical departments were not involved and that no actual functional program had been developed and approved. As chairman of the outpatient committee of the hospital, he called a meeting of all departmental chairmen during late December to discuss the schematic plans. The chairmen were extremely disturbed upon reviewing the plans at this meeting. They felt that the plans did not reflect their judgment of needs and priorities and that they did not provide for a program to accomplish any given set of objectives, except of course a quantitative increase in outpatient clinics and offices. The plans were taken to be the SPP staff's and architect's plans, and were taken to represent their best thinking regarding the building.

The Project Engineer explained that the plans were developed several months prior to December primarily for the purpose of assisting in developing a preliminary general design concept for an office and clinic building and in developing preliminary estimates of building size and cost. They were not intended to remain as shown, and in fact the only reason they had not already been discarded, changed, or approved was the lack of any significant and meaningful planning activity by other members of the planning team. The meeting with the chairmen resulted in the decision to attempt to rework completely the plans through the extensive involvement of the clinical departments.

Subsequently the physician who called the December meeting was appointed Medical Director of this phase of the planning project and was given the responsibility of developing a functional and space program for the office and clinic building. He was to use the SPP engineers as a staff resource and work with the departmental chairmen and other

officials as appropriate in this endeavor. The functional and space program and preliminary drawings were revised, approved, and submitted to the Board of Regents in July 1969. These revised plans reflected the requirements and desires of the individual departments, but the design concept, size, and functional space allocation had not changed significantly from the preliminary plans developed the previous September.

During September 1969 the SPP staff initiated projects to assist in the operational planning for the office and clinic building. These projects involved the design of an information system and the development of a simulation model for use in planning clinic operations.

A new Dean of the School of Medicine was appointed in July 1969. Since that time, he has reviewed existing plans and is making arrangements to re-initiate an extensive and comprehensive facilities planning effort and possibly to revise the master plan.

It will be noted that the Project Manager did not choose to follow the methodology of the original SPP proposal. Consequently, Steps C through J were not accomplished in the manner described previously in this chapter.

General Comments

Several other observations of characteristics of the planning process at the MCG were made which should be helpful in gaining an understanding of this type of process. First, there was a general lack of good information regarding the organization and its present functions. For example, there was no chart of the organization of the institution. The SPP staff discovered much confusion regarding responsibilities and

authorities. Also, there was very little information on the present assignment and use of facilities.

Failure to establish and maintain effective communication was one of the weakest aspects of the planning process. For example, the poor coordination and communication with the clinical chairmen and others regarding the preliminary planning for the office and clinic building resulted in many hard feelings and much wasted time and effort. The vice president in charge of institutional planning was never really involved in the planning. Also, the schools and programs outside of the School of Medicine were left out.

There were many points in the planning process at which special consultants might have made valuable contributions. For example, they might have been instrumental in planning for hospital supporting service facilities, developing a funding strategy, and assisting in the overall management of the facilities planning project. There were several possible reasons that such consultants were not employed. One is that the funds for planning were not sufficient. But it is doubtful that such special consultation would have been fully effective, given the severe deficiencies cited earlier.

In discussions regarding the possibility of and need for obtaining other consultants, the administration demonstrated considerable scepticism regarding their probable value to the planning process. After all, a nationally known consultant had been involved in the planning of the original Talmadge Hospital, which was considered an example of poor planning and design. It was felt that the typical hospital consultant offered only standard and old solutions.

Another feeling often expressed was that the Medical College had as much relevant talent and specialized knowledge among its staff as almost any consulting firm. The real need was to find a way to organize and effectively use the resources that were available internally. This was especially true with regard to the clinical faculty, who were considered expert on the needs for their clinical specialties.

The potential difficulties in attempting to use consultants to help resolve critical issues were demonstrated in connection with the question of whether to build separate pediatric clinical laboratories. The Chairman of Pediatrics felt that they should be built for reasons of teaching, research, and quality patient care. For equally strong reasons the Chairman of Pathology felt that all clinical labs should be centralized. Seeing that an impasse had been reached, it was suggested that an outside consultant be obtained to help resolve the matter. The same impasse, however, was encountered in attempting to select a consultant. The pediatrician wanted a pediatric consultant and the pathologist wanted a pathology consultant.

In an academic institution, there seems to be a need for a considerable amount of the planning, especially for specific programs, curricula, etc., to come from the bottom-up, i.e., to originate with the individual schools and departments. It may be necessary that certain types of planning occur in this direction in order to maintain the integrity of the academic disciplines. There is also an opposing strong need, however, for strong central direction and coordination on many issues, e.g., coordinated planning to change the image of the institution. If the Medical College wants to attract more of the "carriage trade" to its

teaching hospital, because of the interdependency of the clinical departments there must be a strong, coordinated, and integrated effort. At the same time, the clinical departments must be allowed to plan their own programs. These conflicting requirements reinforce the need for creative and forceful leadership.

The project manager position created in spring of 1968 was not effective in providing direction and management for the planning efforts. Not enough time or positive activity was devoted to it. Rather than developing a coordinated, integrated effort, events seemed to shape themselves, and the result was inefficient and ineffective activity. It seemed that primary concern was given to the political aspects of the process and to avoiding personal difficulty and risk.

It was obvious during the planning process that many officials and planners did not always view facility plans as being the objectively determined result of a systematic process, based upon comprehensive and coordinated managerial and program planning. In some cases a certain type of facility plan was promoted as a means of leading toward the development of certain types of programs, rather than being based upon a determination of the functional requirements of a well-developed and approved program plan.

With the requirement for "bottom-up" program planning in the academic institution, facilities become one of the primary "tools" of planning and control available to the administration; other "tools" include budgeting and recruiting. For this reason, as well as the one mentioned above, the development of facility plans may tend to precede the development of functional and program plans. This makes it extremely

difficult if not impossible to objectively determine facility requirements.

Another way in which facility plans unfortunately tend to be determined in advance of functional and program planning is through the recruiting process. Promises regarding facilities are sometimes made in recruiting big-name faculty and professional personnel. Program plans regarding these personnel are not then completed until after they join the staff.

The difficulties and uncertainties regarding relationships with local physicians and with other hospitals in the area continuously plagued the planners. These relationships could have significant impacts upon the clinical programs of the Medical College and upon its facility requirements. While it was anticipated that these relationships would improve and become more clear in the future, facilities planning had to proceed under the present uncertainty because of the impending increase in the size of medical school enrollment. For the most part, this resulted in the Medical School planning to construct enough facilities so that it would not have to depend upon affiliations for any of its basic requirements.

There were many immediate operational types of problems which demanded the time and resources of Medical College administration and officials at the time the long-range planning was being attempted. These seemed to have a disadvantageous effect on the quality of the plans produced and on the seriousness with which personnel undertook the planning. These problems included finances and organization as well as methods and basic operations. It may be significant that, by

early 1970, construction of clinical facilities for the School of Dentistry was almost complete, while new facilities for the School of Medicine were still being discussed and not even the first phase had been finally approved.

In summary, in spite of the good intentions and best efforts of MCG officials and planners, the lack of understanding and knowledge regarding the requirements of this type of planning process and the other difficulties mentioned above contributed to the failure to produce timely and productive planning.

Considerations and Observations Regarding Systems Engineering

The major types of work performed by the systems engineers during the planning project involved the Steps A & B reports, flow-process charts, space estimates, project management networks, and a few special studies, e.g., an economic comparison of one-bed and two-bed rooms.

One factor which limited the number of special engineering studies which were performed was the difficulty in developing a reasonable and acceptable set of assumptions regarding any particular problem which might be studied. For example, in attempting to simulate an outpatient clinic in order to determine the expected optimal number of examining rooms, some of the assumptions and estimates required were as follows:

- Patient demand
- Patient arrival distribution
- Clinic schedules
- Patient scheduling scheme
- The numbers of physicians and students
- Process time distributions
- Patient mix
- Methods and procedures

With the difficulties, inaccuracies, and uncertainties involved in developing these assumptions and estimates for a long-range planning situation, it was questionable whether a detailed operational simulation to determine an "optimal" number of examining rooms would be worthwhile. This type of condition was often the case with attempts to do special engineering studies.

Attempts to develop the framework for engineering studies such as the one mentioned above brought out the importance of other more general aspects of the planning process involving managerial and program planning. They also indicated the importance of timing. The engineering studies must follow some of the more general aspects of planning, and yet must be done early enough to influence subsequent planning and design decisions.

It was also discovered to be particularly important that the systems engineers be selective in their projects. There is an infinite number of real and imaginary problems from which to choose. The engineers must select those real problems which they have the capability to help solve and which promise to be productive in terms of the overall planning process. This requires that the engineers be familiar with the requirements and nature of the entire process and that they be fully participative members of the planning team.

Several major design questions had to be faced fairly early in the planning process. For example, the development of the functional program for the Department of Radiology required a tentative decision regarding the extent to which its facilities and operations would be

decentralized. This decision had implications for organization, staffing, operations, and facilities. There was a tremendous need for expertise and experience in the various technical functions and facilities to combine with the systems engineering approach. In order for the systems engineers to make significant contributions to this decision, they would have to have had extensive experience with the study of radiology operations on which to base judgments, or they would have needed much time for objective study and research. They had neither. The importance and complexity of this particular design problem was confirmed by the Public Health Service supporting a two-year research project on it by the systems engineers at the MCG. Many other design problems involved in this planning process are of similar importance and complexity.

Other constant difficulties for the systems engineers stemmed from the lack of good planning project management and the lack of staff personnel to do general programming work. This not only resulted in the lack of a good framework for engineering studies, but also led to the engineers' having to perform much of the general planning work, instead of performing engineering work. Therefore, much of the value of having systems engineers involved in the process was lost.

In spite of the many difficulties and frustrations encountered in this particular experience, there is great potential for systems engineers to contribute to improvements in the planning and design of clinical education facilities. This will require, however, a better structuring of the other elements and aspects of the planning and design process. It will also require that the engineers gain a comprehensive

understanding of the process to which they are trying to contribute.

This chapter has summarized the observations and experiences of the author as well as the main events, activities, and results of the planning project at the MCG from January 1967 through the summer of 1969. This summary has emphasized the deficiencies and problems involved in the planning process, from the author's point of view, since they indicate many of the needs and characteristics of this general type of planning and since they have implications for the application of management science. The following chapters will draw upon this planning experience as an information and data source for this investigation of the process of planning for clinical education facilities through the systems approach and of the applicability of management science.

CHAPTER VI

THE PLANNING PROCESS

The process of planning within the health educational institution will be different from the processes of planning in business and manufacturing for reasons of certain peculiarities of both the health field and of academic institutions. Some of the characteristics of the health field which influence planning are the prevalence of small organizational units lacking formal or effective coordination and direction, the absence of strong economic or other pressure to move in this direction, and the resistance of special factions to any type of organizational control or direction. Some of the characteristics of academic institutions which affect planning are the multiple and complex goals, aversion for firm organizational direction and control, the requirements of academic freedom, and a relatively lower priority for matters of economics and operational efficiency.

The factors presently generating urgent needs for more effective planning in the health field include those which have led to formal planning in other fields, i.e., complex technology and large investments. More complex technology and larger investments bring about longer-term implications of present decisions and the consequent greater uncertainty and inflexibility. Also, the rapidly-changing science and technology of health care delivery create higher "opportunity costs" for ill-advised decisions.

Although there is a great deal of concern for and discussion of the need for planning in the health field, most of the relevant literature of substance contains primarily discussions of and information on the physical planning and design of specific units of the hospital. Discussion of other aspects of the health planning process is almost non-existent; e.g., the determination of need, organization for planning, setting objectives, managerial decisions, designing efficient and effective systems, methods of analysis and comparison of alternatives, and operational planning.

The largest impetus to planning in the health field in recent years has been federal legislation. The Hill-Burton Program requires hospitals to perform a certain amount of planning before construction funds are approved. This legislation has stimulated the States to pay more attention to the systematic determination of facility needs. It does not cover the entire hospital field, however, and does not provide a comprehensive planning process. Legislation regarding the Regional Medical Programs provides funds and incentives for planning and developing programs to provide better health care for heart disease, cancer, and stroke. This legislation assigns a key role to medical schools as resource centers for knowledge, talent, and leadership. Comprehensive Health Planning legislation is even stronger in its support of regional planning. It is not limited to specific disease categories. It provides funds to establish and operate state and regional planning offices. The regional programs are governed by local personnel representing the health institutions, health professions, and consumers. Their basic

purpose is to achieve comprehensive and coordinated planning toward common goals, and the development of effective and efficient systems for delivering health care.

Most of these programs are still in their infancy. They do not yet provide any significant assistance to the health educational institution in developing its plans for clinical programs and facilities. They do, however, represent factors which require coordination and evaluation.

The first requirement for planning is an effective and efficient process. The remaining sections of this chapter will describe and analyze the process of planning for clinical facilities in a medical education institution. These sections will parallel those of Chapter III, and will draw from the literature on hospital and medical school planning and from experience in the planning process at the Medical College of Georgia.

Types of Planning Involved

For many reasons, clinical facilities have traditionally been constructed to last a very long time and planned for very little flexibility. Many hospital facilities have been used for 30 and 40 years or more. While a legitimate question is whether the planned life should be so long, there will probably have to be dramatic changes in custom, procedures, and the planning and design process before it is significantly shortened. At the present, it seems that a planning horizon of at least ten years is desirable in planning hospital facilities. With the large monetary investment required and the relatively low degree

of flexibility typically achieved, the development of facility designs for ten or more years definitely calls for well-developed, long-range managerial and program plans.

The long-range and strategic plans of the health education institution should consist of at least the following three elements for each of the major functions of the institution, viz., education, research, and service:

1. An assessment of the needs of the "community" which the institution intends to serve.
2. The specification of the role which the institution is to serve in regard to providing for the needs of the "community."
3. The development of the philosophy of the institution with regard to its role, major objectives, and approach.

One of the most critical aspects of specifying managerial objectives in the health education institution is the interrelationships of education, research, and service, and the relative degrees of emphasis to be placed on each.

Specifications for these interrelationships along with estimates of anticipated resource availability are necessary in order to translate general, top-level statements of objectives into more operational terms. Basic to this process of specifying objectives is the question of how to provide for society's future needs--the traditionally over-riding purpose of educational institutions--while at the same time providing much needed service to the "community" in the present--a rapidly increasing demand on educational institutions. This question is probably no more

serious anywhere in the educational world than with the medical school's teaching hospital. The teaching hospital's programs must always consist of compromises between teaching and service functions. Similar trade-offs must be made between these functions and the research function.

The long-range and strategic planning of top management may include the specification of general means of achieving the stated objectives. In most cases, a consideration of alternative means will be involved in the process of establishing objectives, especially for those objectives stated in terms having specific operational and program implications.

The formulation of objectives will involve the anticipation of various aspects of the future of the entire health field, and the selection of the best courses of action to meet the demands of the future and to realize the full potential of the institution in making that future what it is desired to be. It requires an intimate knowledge of the field, and the use of a great deal of intuition and judgment which only those experienced in the field can effectively provide.

Another ingredient which seems to be especially needed in this phase of planning in the health field today is leadership ability. For many existing problems, the needs are relatively obvious, knowledge and technology for solution are available, and financial resources could be obtained. What is lacking is the leadership required to marshal all of these factors and provide the motivation, organization, and guidance to overcome or at least minimize the barriers of tradition, ignorance, apathy, and self-interest. The health-science schools must provide some of this leadership. As a minimum, their leadership could be exercised through the preparation of students for the eventual solution

of these problems, and through the development, evaluation, and demonstration of new models of health-care delivery systems.

Another level of institutional planning upon which facility plans must be based is the selection and development of programs for accomplishing institutional goals and objectives. A program is a unified set of sub-objectives, resources, organizational arrangements, and procedures. The development of program plans is the first step in translating long-range and strategic plans into facility plans.

There will necessarily be many program plans, each to be developed by the organizational unit responsible for the program. There will be educational program plans, which should include descriptions of the programs, numbers of students, curricula, schedules, and resource requirements. Research program plans should include the types, amounts, and resource requirements of the major classifications of research to be performed. Service program plans should include descriptions of the types of services, organizational arrangements, numbers of patients, resource requirements, and new models to be developed.

Operational planning involves the development of methods and systems for carrying out the planned programs and providing the required supporting services. This is largely technical planning. The process of operational planning should include such things as the incorporation of the best available operating equipment and technology, the development of the organization structure, and the design of efficient methods of operation. It also should involve the development of plans to correct or improve present deficiencies in operations. This phase of planning is very closely related to facilities design.

Throughout the entire planning process at all levels there are needs for special and technical project work, including systems analysis and design, forecasting, methods study, and economic analysis. Much of this project work may be performed by a technical staff. For example, architects and engineers working on systems and facilities design are performing project planning.

The general relationships among these three types of planning are illustrated in Figure 3. Obviously, this sketch oversimplifies the actual relationships; the feedback and recycling which must take place in a planning process are not reflected.

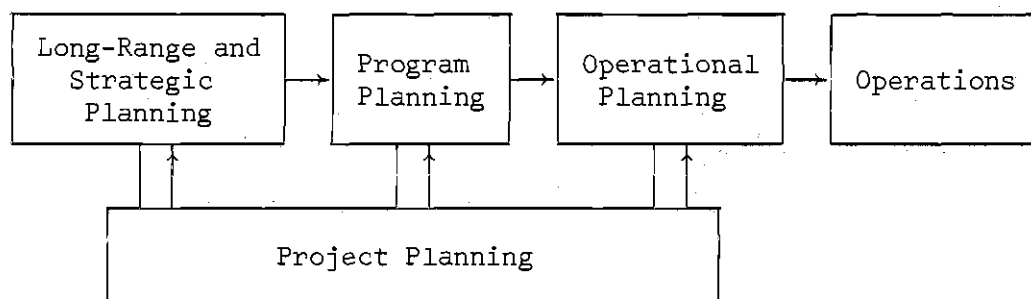


Figure 3. Planning Relationships

The scope of planning required for clinical education facilities is broad and includes a number of elements of the institution's operations. It includes planning for all of those schools which will use the clinical facilities for education and training. The breadth of scope of the required planning is indicated by the following outline of the desirable elements of the functional and space program to be provided the architect. In addition to these elements would be administrative and

financial planning, systems planning and design, recruiting and staffing, developing methods and procedures, and planning for occupancy.

Functional and Space Program¹

- A. Long-Range Projections
 - 1. Quantitative need for health manpower
 - 2. Educational process
 - 3. Health delivery systems
 - 4. New demands for health care
 - 5. Technology
- B. Relationships with Community
 - 1. Role of hospital
 - 2. Relationships with other facilities and institutions
- C. Goals and Objectives
 - 1. Types of students and educational programs
 - 2. Numbers of students
 - 3. Research
 - 4. Service; type and scope
 - 5. Relationships with other institutions
 - 6. Type of hospital
 - 7. Population to be served; in what manner and to what extent
 - 8. Physicians' staff privileges
- D. Program Plans Through Next 10-20 Years
 - 1. Number of medical students
 - 2. Types and numbers of interns, residents, and fellows
 - 3. Types and numbers of allied health students
 - 4. Curricula and schedules
 - 5. Research; programs and levels
 - 6. Types and numbers of patients
 - 7. Clinical departments and divisions
 - 8. Clinical specialties
 - 9. Patient care programs
 - 10. Special services
 - 11. Supporting services
 - 12. Estimated capital costs
 - 13. Estimated operating costs
 - 14. List of sources and amounts of revenue

¹Adapted from *Manual of Hospital Planning Procedures*, American Hospital Association, 1966, 72 pp.

E. Utilization and Service Loads

Types and numbers of

1. Surgical cases
2. Deliveries
3. X-rays
4. Lab tests
5. Physical therapies
6. Occupational therapies
7. Consultations
8. Special diets
9. Laundry services
10. Autopsies

F. Operating Policies and Procedures

1. Referrals
2. Staff privileges
3. Admissions
4. Centralization
5. Interdepartmental patient care process
6. Consultations
7. Schedule of student programs
8. Hours of operation and schedules
9. Standardization
10. Admitting
11. Supplies
12. Communication
13. Storage
14. Logistical system

G. Organization and Staffing

1. Organization structure
2. Types and numbers of faculty
3. Types and numbers of ancillary personnel
4. List of personnel by department
5. Numbers of positions by job title
6. Relationships between schools and hospital
7. Relationships with other institutions

H. Other Hospital Activities

1. Inservice training
2. Auxiliary activities
3. Visitors
4. Recruitment
5. Public health
6. Preventive care
7. Diagnostic screening
8. Meetings and assemblies
9. Religious observances

I. Space Requirements

1. Functional relationships
2. Space sharing and utilization
3. Flexibility
4. Environmental control
5. Expansion plans
6. Description of activity
7. Proximity relationships
8. Systems; logistical, traffic, communication
9. List of all areas
10. Special equipment and physical conditions

The scope of planning for clinical education facilities is also broad in terms of the number and levels of organizational units involved. The administrators of the institution, including the deans, would be expected to assume leadership and provide initiative. The heads of the various schools and departments should also play key roles.

It is expected that the faculties of the schools and departments will be expert in their fields, will be involved in developing new ideas and new knowledge, and will possess an overall knowledge of their fields, where they are now, and where they may be in the future, all of which would seem to be essential in institutional planning. In addition, much of the knowledge and many of the ideas and programs of individual faculty members may have significant implications for the development of institutional program plans. These types of information and their implications for facility requirements may not be adequately reflected in the planning process through the use of the customary operational administrative process without some special effort or special arrangements.

The scope of planning for clinical education facilities also includes obtaining coordination and approvals from many "outside" agencies. One of the most important of these agencies is the governing body or board of the academic institution. In a State university system, it

is this board which must approve and at least partially finance the plans. For an individual institution, the board may be looked upon as a focus of the needs, goals, and objectives of the State, as well as certain other considerations. The board may exert pressures which significantly influence the planning process of the institution, e.g., pressure to increase the student enrollment. Other outside agencies who will likely be involved in the planning process are (1) the Federal government, through its programs of funding and regulation, and (2) professional societies and boards, through political influence, persuasion, and accreditation and licensing criteria.

All of the key elements of the hospital organization should be involved in planning hospital and clinic facilities. These include hospital administration and all supporting service departments, e.g., medical records, pharmacy, laundry, central supply, and food services. This planning should also be coordinated with various outside agencies, e.g., affiliated institutions, the "community" to be served, health planning agencies, the State and Federal governments, and physician groups.

In spite of the many influences which have been mentioned heretofore, the health-science schools seem to have considerable autonomy in setting objectives and choosing means. While some elements of the planning, e.g., student capacities and budgets, will undoubtedly be derived from higher levels, many important elements and objectives will be left to the individual institutions and schools, e.g., curricula, quality levels, research, service, and new models. In addition, virtually all planning related to selecting and designing programs and operational methods will likely be left to the institution and its various schools.

Since there is no technical methodology for setting objectives, this phase of the process will depend upon experience, intuition, and judgment, and may even involve a relatively high political content. The political content may be especially high in establishing objectives related to the teaching hospital, since these objectives must be carved out of a complex and conflicting mixture of considerations involving community needs, educational objectives, accreditation requirements, governmental planning and regulation, affiliated institutions, the private practice of medicine, etc. To the extent that this process allows autonomy in setting objectives and selecting means, the type of planning which has previously been called *developmental planning* exists.

Many aspects of the process of planning for clinical education facilities are adaptive in nature, i.e., dependent upon and responsive to the environment of the institution and outside influences. Some of these outside influences have been mentioned above. To illustrate further, the Federal government originates plans for the development and support of certain aspects of education, research, and service programs in the health field. These plans are based upon what the government sees as being needed in this country and, it might be said, what appears to be politically expedient at the time. Since the government usually puts money behind these plans, and since the health science schools are to some extent dependent upon the government's financial support, the schools usually must adapt their plans to follow the directions set by the government. For State institutions, a similar financial influence may also be exerted by the State government, but usually not to so large an extent since State funds are generally used for basic support of

existing programs rather than for developmental purposes. The primary influence of the State government is through the governing body of the institution.

The primary objectives of the health education institution involve the satisfaction of health care needs of the public through education, research, and service, including the development of demonstration models. Public demands provide significant indications of these needs. Therefore, the institution is responsive to public demands in the development of its plans, especially plans for the teaching hospital. While many of the more general public demands are expressed through the Federal and State governments, there may be other significant demands upon the institution from the local community. The institution must, to a certain extent, be responsive to these demands since its teaching hospital must function as an integral part of the medical and health community, and since some of its objectives may involve providing certain types of service to the local population.

Other outside elements to which the health-science schools are responsive in their planning are professional societies, boards, and agencies. This is especially true with regard to the medical profession. These groups influence planning through accreditation criteria, the licensing and certification of professionals, tradition, setting standards of practice, direct and indirect influence on their members, and political action.

It is obvious that there are several outside influences affecting many aspects of planning for clinical education facilities. Therefore, much of the planning is adaptive in nature, and the process tends

to become one of programming to accomplish politically derived objectives.

The process of planning for clinical education facilities also involves many elements of allocative planning, i.e., the allocation of resources among competing uses in those cases where there are quantitative measures of effectiveness and where the optimality criterion is the primary guide. This process is an objective one, and usually involves the comparison of alternatives on the basis of technical and economic measures. It appears that, because of a lack of specificity in objectives and a lack of good quantitative measures of effectiveness, allocative planning plays a minor role at and above the level of program selection and design. As the process moves closer to operational planning and design, allocative planning comes more into play. For example, alternative supporting service systems and operational facility designs are more frequently selected on the basis of their costs and benefits.

Another type of planning required involves the introduction and development of new arrangements and programs for the accomplishment of dramatically new objectives which may not have received general acceptance and support within the institution. Such seems to be the case, for example, in the introduction of the "systems curriculum" in medical education, and in the development of "comprehensive health care" programs under the auspices of the institution. In the case where major new facilities are being planned, and where these facilities must be specifically designed to accommodate these new programs, a process of rapid and radical change may be required. The process of mobilizing personnel and resources and guiding change toward the yet unaccepted new objectives

has been called innovative planning. With the major problems facing health institutions today, and with the complexity, resistance to change, lack of coordination, and disunity which presently exists within the health field, elements of innovative planning will probably be very important in the process of planning for clinical education facilities.

Finally, almost all of the various types of plans will be produced at some point in the process of planning for clinical education facilities. Policies and objectives will be developed for the institution and for each relevant subdivision. Operational plans will be developed for each major organizational unit and for each major function, including education, research, patient care, and supporting services. Those procedures having implications for facilities design will be designed. And, both capital and operating budgets will be prepared. All of these types of plans will be combined into what the planning literature calls a "program."

The Nature of This Planning Process

Since facilities must be planned and designed to accommodate the programs of the institution and to enhance the attainment of its objectives, the process of planning for clinical education facilities is related directly to the institution's long-range and strategic managerial planning process, i.e., the process of setting goals and objectives and developing general program plans for the future.

Emphasis on the *process* of planning rather than specific *plans* is even more important in relation to the academic and health industries than to business corporations. These industries are presently in a

state of badly needed innovation and change. To develop plans so rigid that further innovation and change would be inhibited for any significant period of time would seem to be most unwise. Also, the basic purposes and modes of operation of institutions in these industries would seem to require a relatively high degree of freedom of action. Both the teacher and the health professional need the opportunity of relative independence and freedom in their functions in order to perform successfully; the same is true of the institutions and organizations in which they operate.

This need for freedom of action does not mean that the various individuals and organizational units must be allowed to operate in a completely uncoordinated and undirected fashion. In fact, the chaos and confusion which often results from lack of direction and coordination can be more restrictive of freedom of action than authoritarian control. A good planning process is needed in order to interrelate and coordinate the objectives and activities of the various individuals and organizational units. Such a process at the institutional level can provide a structure for more productive action and motivate people at all levels to perform their own planning more effectively.

Planning will result in meaningful action only through the involvement of those who are operationally responsible for the action. Plans which are formulated completely by an "outside" group often have no impact on the actions of those with operational responsibility, although the plans themselves may be theoretically sound. For these and other reasons, the planning process should be people and action oriented. Its basic purpose is to influence present decision and actions so that objectives are achieved in the future. In the present setting, this

means that heads of academic programs, clinical services, and hospital supporting services should be heavily involved in the planning process.

In order to accomplish all of its requirements, the planning process should be organized as an integral part of the administrative and managerial function of the health educational institution. It should be broadly based, organized, coordinated, systematic, and yet dynamic enough to allow continual re-examination. Greater and longer-lasting benefits can be expected from improvements in the process than from concentration on the improvement of specific plans, as is so often the case.

Setting goals is the first and probably the most important part of planning since it establishes the direction for all that follows. It is reportedly the most poorly done part of corporate planning, and is undoubtedly the most difficult part of planning in the health field. While it is relatively easy to state goals regarding education and health care in general, abstract, non-operational terms, it is much more difficult to state them in specific and operational terms which will provide clear guidance in selecting and designing programs and facilities. This is due in a large measure to the lack of operational definitions of good education and good health care and the lack of acceptable criteria and measures. The implication of this situation is not that goal setting is futile in the health-education institution, but rather that those people responsible for making the judgments required to set goals must also be heavily involved in the process of selecting and designing programs and facilities. Dependence upon judgment is carried to a much lower level in planning than would be necessary if clear operational objectives, criteria, and measures were established.

Without the identification of the elements of good education and good patient care and without a capability for measuring them and relating them to operational functions, technical staff planners and specialists can play only a minor role in program selection and design. The planning process must integrate the talents of the technical staff planners and specialists with the experience and professional judgment of operational managers and administrators, with the latter playing the major roles through program selection and design and even through the specification of many operational concepts of facilities.

Because of the need to involve the academicians and clinicians in the process of planning for clinical education facilities, and in consideration of their customary lack of planning orientation and experience, the developmental approach would seem to be necessary. Under this approach the first planning projects should involve objectives which are short-ranged and limited enough so that participants can gain experience and confidence based upon success within a relatively short time. The scope of projects are then expanded in relation to growth in planning skills, and confidence among the institution's personnel.

As is true in the planning field in general, there are few established procedures and techniques for planning for clinical education facilities. This is clearly indicated by the literature related to this field. While it is not expected that a scientific or even a mechanistic methodology will ever be developed for this process, there are many opportunities for making it more organized, systematic, rational, and, hopefully, more successful.

Although one of the primary objectives of the process should be to achieve maximum rationality in planning, the roles of objective and scientific methods and approaches are limited by many factors, including the following:

1. The value judgment content of the process.
2. Incomplete information.
3. Lack of time and resources for thorough study.
4. Inappropriateness of data on past operations in a process which has as its primary purpose establishing new patterns for future operations.
5. Inadequacy of present objective and scientific methods and approaches in solving many of the most important problems in such a process.

It is apparent that new directions, approaches, and methods are called for in the health and education fields. Planning which involves an extension and gradual improvement of old forms of operation may very well not be adequate to meet even the short-range needs. To fulfill the role that is needed for planning in these fields, a great deal of imagination and creativity will be required.

As indicated in previous paragraphs, planning for clinical education facilities should be a comprehensive process involving all of the major elements and activities of the organization. Because of this, the selection of the critical elements for study and redesign, timing, and organization are of utmost importance.

Because of the scarcity of acceptable data, the incompleteness of knowledge regarding health care needs and the operation of the health care system, and the radical changes anticipated, analytical-quantitative forecasts and predictions for long-range planning in the health field are

probably less accurate and reliable than in business and manufacturing. The use of analytical-quantitative methods of forecasting should be carefully considered and viewed critically. About the best that can be done in many cases is to attempt to anticipate the possible futures so that the right risks are taken, and so that the appropriate flexibility to respond to major anticipated developments can be achieved. A valuable approach in this connection is the performance of sensitivity analyses on alternative plans and designs; i.e., test each alternative against the possible futures in order to predict results under the various conditions.

"Uncertainty absorption" is another important aspect of this planning process. Assumptions and decisions made at various levels of the planning organization tend to "absorb" some of the actual uncertainty which exists, so that subsequent levels perform under less apparent uncertainty. This is an important consideration in the organization and management of the planning process. Some of the uncertainties will involve the educational process; others will involve the patient care process, supporting services, and managerial and administrative matters. Each type of uncertainty may require a different type of person to make the necessary assumptions and judgments.

Steps Required

The first and most important step in planning is the setting of objectives. The goals of the institution establish the framework and the direction for the following steps in planning as well as for day-to-day managerial decisions. Even though this is a very critical step, it

reportedly is the poorest aspect of planning in the health field today. Most managers and planners go into programming too soon and devote most of their attention to it. The following quote indicates one author's view of the present situation:

All too often, health institutions are artfully designed and skillfully manned ships at sea with neither compass nor destination, and with little idea of whether the artful design or the skilled staff are really suited for the voyage ahead.²

As pointed out earlier, it is relatively easy to state lofty and general objectives for health institutions; but, in order to provide effective guidance for the planning effort, objectives should also be stated in more specific and operational terms. They should be well formulated and coordinated; priorities would be helpful. Whenever possible they should be quantified to facilitate managerial control and the measurement of progress. For example, certain objectives may be stated in quantitative terms such as student capacities, student-teacher contact time, numbers of inpatients and outpatients, lengths of patient stays, student-patient contact, and numbers of residents and interns.

An approach to selecting objectives has been suggested by Hall, as follows:

- (a) Put the objectives on paper.
- (b) Identify means and ends.
- (c) Test to see that the objectives at one level are consistent with higher level objectives.
- (d) Test that the subset of objectives at each level is logically consistent.
- (e) Make the set of objectives complete.
- (f) Give each objective the highest possible level of measurement.

²Sigmond, Robert M., "Health Planning," *Dimensions and Determinants of Health Policy*, The Milbank Memorial Fund Quarterly, Volume XLVI, No. 1, January 1968, Part 2, pp. 91-117.

- (g) Check the objectives to see if each is physically, economically, and socially feasible.
- (h) Allow for risks and uncertainties by various available techniques and by selecting an appropriate decision criterion.
- (i) As a step in settling value conflicts, isolate logical and factual questions from purely value questions.
- (j) Settle value conflicts.³

Planning for facilities tends to require more specific and quantitative statements of objectives than management would otherwise wish to make at the time; e.g., the nature, size, and operating characteristics of new programs; the numbers of students, their schedules and flow patterns; the patient population to be served, and the types of services to be rendered; curricula; and the nature and magnitude of the research programs. Planners will probably have to push for these decisions by showing their relevance and importance to good facilities planning and design.

There should be a hierarchy of objectives. The highest level may be very general and abstract. Lower levels should be more specific and concrete as well as realistic and attainable. Each organizational unit should have a set of objectives relevant to that unit. Some of the objectives for a particular unit are likely to be imposed by higher levels, others may originate within the unit, and still others may develop in response to pressures from lower levels. In an academic institution most of an organizational unit's objectives will probably originate from within the unit.

Care should be taken to develop the objectives in a manner which

³Hall, Arthur D., *A Methodology for Systems Engineering*, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1962, pp. 108-109.

will allow the planning process to be dynamic, involving continual feedback, adjustment, and change. Too much specificity and rigidity in the statement of objectives may limit the possibilities of creative and productive decision and action within subordinate organizational units.

This critical phase of the planning process deserves special and continual attention. Poorly developed objectives will probably lead to inadequate planning and poor performance in the future.

There will be many elements involved in the planning for clinical education facilities for which reliable, factual information is not available or cannot be easily produced. Therefore, the next step is to make the necessary assumptions regarding these elements. These will include assumptions regarding the internal and external environment of the institution for the present and for the future. For example, assumptions must be made implicitly or explicitly regarding the future structure of the health-care delivery system and its requirements for health personnel, the future structure of the educational process, governmental influence and support, trends in the economy, and possible public demands upon the institution. It should be apparent that the making of such assumptions is an integral part of the managerial process of the institution. Key managers and faculty members at various levels in the institution should be involved in making these assumptions for planning, along with consultants and outside agencies as appropriate.

The institution's management should agree on a set of assumptions for planning. As many as feasible of these assumptions should be identified, verbalized, and communicated to the various heads of organizational units and to members of the planning staff, e.g., the facilities

planning project manager, architect, and consultants. Since the collection and analysis of relevant data tends to improve assumptions, the managers involved in planning may wish to refer some questions regarding possible assumptions to the appropriate personnel, including the planning staff, for investigation.

Following the statements of objectives and assumptions should be the development or identification of alternative means, or courses of action, for the institution to pursue in order to achieve its objectives. As indicated earlier, this involves the specification of alternative programs, resources, methods, etc., based upon a creative and imaginative search for possibilities.

Some specifications regarding general means for achieving objectives will undoubtedly be developed by the top management of the institution, e.g., whether or not the institution will operate its own hospital, the types of affiliations with other institutions which will be sought, the level of resources expected for various types of programs, the institution's philosophy regarding the provision of service to the community, and the implications of the institution's philosophy regarding the educational process. Within the framework set by top management, heads of academic and operating units should develop more specific and more detailed ideas for alternative programs. This is a very critical phase of the planning process since the results of planning can be no better than the alternatives considered.

Alternative means must then be evaluated against the criteria derived from the previously developed objectives, constraints, and assumptions. The evaluation must also be made in terms of the major

possible "states of the future" for the institution and its environment. Projections, some quantitative and others qualitative and judgmental, of the anticipated results for each alternative under each possible state of the future should be made, the results should be compared with regard to the decision criteria, and then the decision makers should select the best course of action based upon this comparison. Some comparison may be quantitative, but many will involve value judgments. The final decision must be a managerial decision.

As an example of the above process, the planners may wish to choose one of two alternative service programs based upon their anticipated results, including their costs and their contributions to the educational process, under the most likely levels of future governmental influence and intervention in the health field. Also, the planners may need to compare two or more alternative facility designs in terms of their costs, flexibility, and operational effectiveness under various assumptions regarding trends in health-care delivery and public demands for health care. On a different level, there may be a need to compare various operational systems, e.g., supply and logistical systems, in terms of their cost, effectiveness, and flexibility under various assumptions regarding possible economic and technological developments. There will be many such evaluations required, each calling for the planning framework of objectives, constraints, assumptions, and criteria.

Implementation, of course, follows the selection of the desired course of action. For the process of planning for clinical education facilities one of the primary implementation phases is the development of the architectural plans and designs for a building which will house

the planned programs and enhance the accomplishment of the institution's objectives. This phase is accomplished by the architect and the planning staff assigned to work with him.

Most of the implementation of planned programs may have to follow the construction of the building; however, some preliminary phases may be accomplished prior to construction, in preparation for full operation afterward. Implementation of programs will, of course, be accomplished by the personnel responsible for their operation, i.e., the heads of academic departments, clinical services, hospital administration, and hospital service departments.

The final step in the planning process is evaluation of the results of implemented programs, feedback of the evaluation to management and staff planners, and adjustments and changes as necessary for improving performance relative to objectives. This "final" step is not the end of the planning process in the sense that planning stops here. Even with planning for facilities there is a continuous need for revision, updating, and change. Facility requirements should be continually evaluated along with the process of continuous managerial planning.

As noted earlier in this paper, the accomplishment of the steps of the planning process probably will not follow a neat sequential order. There will be information feedback loops and recycling through all of the steps of planning, so that during the planning process certain activities in many of the steps may be taking place simultaneously. Planning itself is a continuous process of change, updating, and recycling.

Management of the Planning Process

Several characteristics of the management of health-education institutions tend to make the planning process somewhat different from that of business and manufacturing. In most cases there is no strong central authority for coordination, decision making, and implementation. This is true of the health field in general, and therefore influences the manner in which the health-education institution must plan its teaching hospital and service programs. A primary example of this condition is the autonomy and independence of the individual physician and the resistance to any change in the basic pattern of private practice. Not only does this influence institutional planning in relation to its external environment, it also affects internal management and planning through the attitudes, practices, values, and political inclinations of the physicians on the staff of the teaching hospital and the faculty of the school of medicine.

This characteristic of autonomy and independence is also found within the academic structure. Schools and academic departments are allowed a high degree of autonomy in setting their own objectives and developing their programs. Also, throughout the administrative structure, management is limited in its use of strong planning and control because of possible infringement on "academic freedom."

With this lack of strong central authority and control in the administrative structure, staff planners are more likely to become involved in the implementation of plans, especially those plans which involve more than one department. One reason for this is that, with decentralized authority and operations, the central administrative

structure is usually very thin and the administrators may not be willing or able to become heavily involved in the details of implementation. The staff planners may be called upon to perform major parts of this function. Also, since planners desire to see their plans implemented and operating successfully, in the absence of strong central authority and control to accomplish this they are likely to want to be more involved in implementation than would normally be the case.

The basic planning framework and strong support for the process of planning for clinical education facilities would be expected to come from the chief administrative official of the institution. Below him, the deans and heads of the various departments should develop more specific objectives and assumptions, specify policies and constraints, provide leadership in their areas, and actively perform certain phases of the planning. Most of the detailed planning, however, such as the design of specific programs, will be performed at the level of departmental chairmen, hospital administration, and heads of hospital departments. In general, the chief administrative official, deans, and heads of schools would be expected to provide the opportunity, necessary support, encouragement, and the coordinated framework for planning and development at lower levels.

The sequencing of decisions and activities through the organizational hierarchy and operational network requires considerable managerial attention. Organization for this process, which would include responsibility assignments, effective communication methods, and coordinated timing, is essential to its effective and efficient functioning. It may

require a planning staff in addition to a significant amount of the managers' time.

Organizational arrangements for the process of planning for clinical education facilities should be broad in scope. Almost all organizational units of the school of medicine and the hospital will be involved directly. Depending upon the objectives of the particular institution and the local situation, other schools and areas may need to be included in the organizational arrangements, e.g., dentistry, nursing, and allied-health schools.

The large number of planning elements and activities which must be scheduled and coordinated is indicated in the outline for a functional program on pages 178-80. Still, not all elements of the institution's activities can be explicitly considered and planned in this process, if for no other reason than limitations on time and resources. The principle of "diminishing returns" must be remembered. The selection of those activities which will be explicitly considered is a critical aspect of managing the planning process. This selection should be made through some combination of the judgment of managers and planning specialists.

The selection of critical planning elements is also important in the effective use of a planning staff. Not all major planning questions can be thoroughly investigated and studied by any one institution. Usually, only a relatively few major issues can be thoroughly studied by the planning team. The resolution of other issues must depend upon the experiences and judgment of those involved in the planning process and whatever can be learned from the experience of others at other locations.

A great deal of the planning and almost all of the implementation must be performed by those with primary operational responsibility for the activities being planned. The central issue in managing the process of planning for clinical education facilities, then, seems to be the involvement of responsible personnel from the various organizational units and functional areas in a way which will help them plan more effectively and which will result in a coordinated set of objectives, assumptions, and specific plans.

One of the main propositions of this paper is that planning for clinical education facilities should be integrated with the continual institutional planning process. In this manner, the appropriate direction, timing, and personnel involvement are more easily and effectively obtained. Also, the planning for facilities will be a more-or-less continual process, as it should be, since there is a continual need for alteration, renovation, re-allocation, and new construction. In addition to the contribution of this approach to better facility plans, the broad involvement and close association with the institutional planning process will enhance acceptance of plans and will lay the groundwork for operational and occupancy planning. Another possible by-product of broad involvement in planning is its contribution to the development of better managers.

The planning process consists largely of the development, analysis, and communication of information in support of decision making involving the future. The amount and complexity of information handling involved in the process of planning for clinical education facilities requires systematic methods and good record keeping. Much of the data

and information needed and desired will not be available from within the institution. This is largely because of the fact that planning relates to the future whereas most available data relates to the past. Accounting and other record keeping systems within the institution are seldom designed with planning needs in mind. Much of the available data is in the form of averages, aggregates, and other transformations of raw data which do not reflect statistical properties and other patterns of variation which are valuable in operational planning. Also, many hospitals lack good cost records, such as those of cost accounting, which would be of value in some aspects of planning.

The institution in which planning is being performed is not always a good information and data base for another reason. Most planning for clinical education facilities is likely to involve significant changes in certain objectives, programs, levels of activity, and modes of operation. If this is the case, much of the data from the past will not be applicable in the future. Under these conditions and with anticipated changes in the external environment, good data and information for planning purposes are scarce.

There is likely to be a tendency to devote large amounts of time and resources to investigation and study to produce better information for planning. While much investigation and study may be justified, the planning process will no doubt have to proceed with incomplete information on many questions. The problem of determining the appropriate tradeoff between the value in time of moving ahead even with incomplete information and the value of obtaining additional information by taking more time for study is a critical one in the management of the planning

process. There is a point of diminishing returns in the development of additional and more accurate information.

The importance of good communication in the planning process has been discussed previously. This will not be further discussed at this point, except to point out that the large number of people likely to be involved in the process and the necessity for a participative approach to planning in an academic institution underscore the importance of good communication. The planners may find the maintenance of effective communication one of the most demanding aspects of their job.

The staff of a health-education institution, and especially that of the teaching hospital, will usually be under the pressure of current problems and demands in their education, research, and service functions. Also, for reasons pointed out previously, they may not be inclined to do long-range planning. There will probably be a tendency to put planning matters off in deference to more immediate needs. This seems to be a common occurrence in planning for facilities, with insufficient functional and program planning being performed on a last-minute, "crash" basis.

A time discipline, including schedules and deadlines, is essential to the effective and efficient management of the planning process. Timing and coordination of the various phases of planning are required in order to avoid wasted effort and time. The process of planning clinical-education facilities is a long one at best. Minimum estimates of the time required range from one to two years. Most reported experiences indicate a much longer time--even up to ten or more years.

Approaches and Methods

Determining which planning elements are to be developed sequentially and which in parallel is an important aspect of developing an overall approach to the planning process. Parallel development has many advantages and will probably help achieve better integration of activity and greater efficiency in the planning process. Having many elements in planning at once under a well-managed process allows interaction, feedback, and adjustment among the elements as planning progresses. As an example of this, the planning of programs and the search for funds might be going on at the same time. Initial program objectives might provide enough information to start the search for sources of funds; indications of fund availability from particular sources might then provide more specific direction for and constraints on more detailed program planning. Performing both elements in parallel under the appropriate coordination will probably be more efficient than a sequential process.

Most of the broad elements of the process probably can be carried out in parallel. After the initial statement of the objectives of the building program, other planning elements can be started while the process of refining and developing a more detailed and complete hierarchy of objectives continues. For example, many elements of architectural planning can begin, such as site planning, developing design objectives and criteria, and obtaining ideas and information from other institutions. General planning for many operational systems, e.g., supply, communication, and logistical systems, can also begin.

Although major elements may be carried out in parallel, there are many desirable and some necessary precedence relationships among various

phases of the elements. For example, the architect cannot (or should not) develop a detailed program of facility requirements until the institution has developed its functional program. Specific objectives cannot be developed for hospital service departments until clinical departments have developed specific objectives and programs, which may in turn depend upon an indication of the availability of capital financing. A formal application for Federal funds cannot be submitted until an architectural program of facility requirements has been prepared. Specific plans for major operational systems probably cannot be completed without some knowledge of the architect's building concept and various architectural constraints. So we see that, even though the general approach involves parallel development, a sequencing of various phases of each major planning element is required. Therefore, there must be a combination of parallel and sequential development.

Another important consideration in selecting the general approach to planning for clinical education facilities is the relative emphases on the inside-out and the outside-in approaches. Under the outside-in approach, primary emphasis in developing the institution's objectives and strategy is placed upon the anticipated needs and desires of elements of the external environment. An attempt is made to translate these anticipated needs and desires directly into institutional objectives and programs. This definition seems to apply to the usual approach in planning a community hospital, for example. The educational institution's teaching hospital, however, will probably involve a much less clear and direct relationship with its environment. While its ultimate goal is the satisfaction of certain anticipated needs and desires of its external

environment, the manner in which it chooses to accomplish this goal depends more on value judgment within the institution. Its objectives are more indirect and long-ranged than those of the community hospital. They involve not only a response to the environment, but also the provision of leadership for the health-care "community" and the development of new "needs" and desires. In certain respects, it involves more developmental and innovative planning than adaptive and allocative planning. There will probably be a strong emphasis on internal strengths and resources and their use in satisfying selected long-range needs and in providing a form of leadership for the health field. In other words, the inside-out approach seems to be more suited to many aspects of the process of planning for clinical education facilities.

It should be noted, however, that a mixture of the inside-out and the outside-in approaches is required. The outside-in approach will probably come into play in determining the numbers and types of students, and in responding to Federally sponsored and financed programs, i.e., going where the money is.

The planning approach selected should also provide for the effective handling of uncertainty. Uncertainty should be explicitly recognized and dealt with. Several considerations in this respect will be mentioned. First is the need for recognizing that uncertainties are absorbed in the process of making assumptions, judgments, and decisions. The structuring of the process for planning clinical education facilities should be such that the various uncertainties will be resolved by the people most appropriate in terms of qualifications and responsibilities.

Uncertainty absorption is also an important consideration in the coordination and sequencing of the various phases of planning. With sequential elements, an assumption or a decision made in one phase will very likely constrain the alternatives considered in the following phase. In such cases the appropriate sequence may depend upon the nature of the uncertainties involved.

In some cases, decision analysis models may be useful in searching for optimal or near-optimal alternatives and in selecting an alternative which suits some decision criterion under the existing conditions of uncertainty. These will be further discussed later in this paper.

One of the primary methods of handling uncertainty in the planning process is to build-in flexibility. Sensitivity analysis is helpful in developing the right types of flexibility; i.e., consider the results of each alternative plan under the conditions of each possible future, and incorporate changes in the selected plan which would lead to more satisfactory results under the various possible futures. Since the incorporation of flexibility usually adds to initial costs, a major decision problem is to balance the present costs of flexibility against possible future costs for changes which might be necessary without that flexibility.

The problem of achieving flexibility is involved in most of the major elements of planning for clinical education facilities. For example, the desire for extensive flexibility in clinical education programs may lead to relatively greater emphasis on affiliations with other hospitals rather than the development of more "in-house" programs. Uncertainty as to the future growth of outpatient programs may result in

the design of outpatient facilities with convenient expansion or conversion capabilities. Anticipation of future trends in wages and in the national economy may result in the provision of shafts and additional floor space for the future installation of mechanical conveyors in the building even though their installation is not economically justified at the time of construction. Many such uncertainties may justify various methods of achieving flexibility on the basis of expected costs and benefits.

Another important method of responding to excessive uncertainty in the planning process is to shorten the planning horizon. This seems to be a very common reaction in health and academic fields, and is often carried to the extreme of shortening the planning horizon almost to zero, and doing little real planning. This alternative is not feasible in the process of planning for facilities however; someone has to make decisions and plans regarding the future, no matter how poor they may be, in order to develop facility plans. The question here is not whether to plan, but how to plan and how much planning should be done.

It would seem, however, that a feasible alternative deserving serious consideration in the process of planning clinical education facilities is to shorten the planned life of the buildings. It presently is customary to plan clinical facilities for a very long life. With the rapid changes taking place in all aspects of the health field, a more economical building planned for a shorter life might result in more effective and economical operations.

An approach involving quantification and measurement of as many as possible of the variables critical to the planning and design of new

clinical education facilities would tend to result in better plans. Some of the difficulties of quantification and measurement in the planning process in general were pointed out earlier. There are other significant complications in the process presently under consideration. One of these complications relates to quality; there is no set of quantitative measures generally agreed upon which indicate the quality of patient care, and therefore relatively few quantitative indices of quality are available for use and guidance in the planning process. For example, the evaluation of alternative facility designs relative to the quality criterion must depend primarily upon expert judgment. Another difficulty is that very little useful data and measures are available relative to the operational characteristics of hospitals; few standards are set, relatively few operating records are kept, cost accounting data is often not available, and most units of measure for workloads are inconsistent and inaccurate. This lack of data and meaningful measures makes it extremely difficult to analyze present operations, identify operational deficiencies, make projections, and compare alternatives.

Regardless of the difficulties, many measurements will be required as a part of a good planning process. Selection of the approach to and methods of planning should involve decisions as to what measures will be made, how to make them, and the accuracy required.

Another set of important measures consists of those which indicate the progress of the planning process and those which may be used to evaluate results of the process.

Visual and graphical exposition are useful methods in the planning process. Portraying concepts and data in visual form can show

relationships and provide insights which would otherwise be missed. In the process of planning clinical education facilities, visual descriptions may be useful throughout the process and especially as the program plans begin to be translated into facility plans. The use of sketches showing facility design concepts, approximate sizes and arrangements, etc., may be beneficial even in the process of writing the program-of-requirements. Not only do sketches make it easier for some people to conceptualize facility requirements, but they also help in the estimation of certain general support space and in identifying possibilities of space sharing. Another visual aid which should be of special value is a project management network.

Many industrial and systems engineering methods will be useful in the process being studied. Most of the traditional methods can be used in the facilities planning and design phases. Certain of these methods may also be used in managerial and program planning. Chapter VII will discuss further the matter of technical and analytical planning methods.

Behavioral Considerations

As has been the case in corporate planning, there may be considerable resistance to any extensive and formal process of managerial planning in support of the planning and design of clinical education facilities. Among the reasons for this is the lack of time. With the many current problems facing university medical centers, it may be extremely difficult to find time for long-range planning. Combine this with the many uncertainties and the rapid change taking place in the health field today, and it may seem almost impossible to conceive of

successfully planning for next year, much less for 20 years from now. Many may feel that the wisest step in planning would be to solve present problems. For example, a strong organization developed during the next few years may produce better results 20 years from now than any formal, long-range planning process.

Another possible reason for resistance is that formal, long-range planning is new and foreign to many in the health field. Most health institutions and health professionals have not been very much involved in such a process and may be basically disposed to resist it for economic and professional reasons, many of them selfish in nature. To many, planning may imply control and thereby present a challenge to present interests and modes of operation.

Because of no previous training and experience in formal, long-range planning, the management and staff of the institution may lack confidence in their knowledge and skill in planning, and therefore resist undertaking a planning process requiring a lot of their time and resources and with very uncertain returns.

Other reasons for skepticism and resistance to formal planning exist. Among them is the fact that specific objectives in the fields of health and education are very difficult to establish. At best, they are usually very general and abstract, implying decision criteria for which there are no good measures and which are often contradictory in operational terms. Since the first step in planning is setting goals and objectives, many may become discouraged with the difficulties at this point.

A related difficulty is that planning raises many sensitive and complex issues simultaneously. The difficulties of multiple alternatives, political implications, lack of information, and uncertainty may send many managers back to more pressing, yet more manageable, current problems.

Certain other characteristics of the professionals who work in a medical center tend to act in opposition to an effective planning process. One is the fact that, on the average, individuals are not at one institution for very long periods of time; i.e., turnover is high. Since an individual may not expect to be with an institution over an extended period of time, he may not identify with the institution and its long-range success sufficiently to devote much of his time and resources to long-range planning. His personal success may be more dependent upon short-term performance and upon other professional activities than it is upon effective long-range planning.

If the institution has not previously had an on-going, formal, managerial planning process, it may be better to introduce such a process slowly, giving institutional personnel the opportunity to learn and gain confidence from relatively small and short-range planning projects. Professional planners and consultants can help in initiating the process by providing guidance, information, and training. In the environment of the medical center, it is especially important that the planning process be people and action oriented rather than plan oriented. It must be a managerial process, and should involve all of the organizational units principally interested in and responsible for the outcome.

General managerial planning within the health education institution will probably be the weak form of process-oriented planning; i.e., there may be little bargaining and negotiation and no formally written and approved managerial plans. Results and implementation may be expected to derive from the participation of the principal interests in joint consideration and dialogue on planning issues which hopefully leads to wider awareness of problems, a common information base, common objectives and assumptions, more responsible decision making, etc.

It is likely that the process of planning for clinical education facilities will involve a high political content on several levels. Since we are considering an educational institution, there will be State political considerations in establishing goals, obtaining approvals for programs, and obtaining funds. The Federal Government also will probably be involved in setting directions for the educational and clinical programs and in funding. Professional and educational associations will probably exercise certain influences through guidance, licensing, and accreditation.

Other political factors may be introduced into the planning process through the development of affiliations with other clinical and educational institutions. The extent to which other clinical facilities are used for educational purposes will depend upon the desires and resources of the educational institution as well as the political possibilities.

Depending upon the type of clinical programs to be undertaken, one of the critical issues in developing plans for them may be the arrangements and agreements with private-practice physicians and medical

associations necessary to obtain the patient input. In some cases this is a sensitive political problem, since physicians may view the teaching hospital's programs as socialized medicine and the full-time faculty and staff as engaged in the corporate practice of medicine, and they may consider both as competition to private practice. The institution's programs must be developed in a way which will help to overcome these attitudes.

There are also politics internal to the institution which affect the process of planning for medical education facilities. With the traditional lack of formal and coordinated programs of planning, and with the previously discussed lack of specificity in goals, lack of measurable criteria, professionalism, and the requirements of academic freedom, there is considerable opportunity for political action in the planning process. The composition of the medical staff, i.e. primarily specialists, contributes to this situation. Most specialists are not very flexible as to the position they fill and the role they play in the programs of the institution. Their jobs and careers depend upon developments regarding their specialties. In such a situation, political action may be a significant factor in the planning process.

There must, of course, be a combination of political and technical planning in the process being studied. Some of the limitations on technical planning are indicated by the following quote:

The relative influence of a technical planning function in guiding social and economic change will depend chiefly on five variables: (1) the clarity of system objectives, (2) the extent of consensus about them, (3) the relative importance that politicians attach to them, (4) the degree of variance relative to objectives expected in the performance of the system, and (5) the extent to

which a technical (as contrasted with a purely political) approach is believed capable of making system performance conform to these objectives.⁴

In spite of its limitations, there is significant potential for the application of many more technical methods in the subject process than have heretofore been used. The same is true of the application of technical methods in the design of the facilities themselves, even though this phase of the process already has a relatively high technical content.

In any substantial planning effort, there is likely to be a need for a full-time planning staff. In an academic institution where members of the faculty will probably be "experts" in the programs being planned, technical planning specialists will probably be the most needed type of planning staff. In addition to a certain degree of familiarity with the health-education field, other characteristics found important in the corporate planning process will also be needed in this process, i.e., personal adaptability, analytical flexibility, the capacity to conceptualize, the ability to continually adjust, and self-starting and self-sustaining interest. In the complex and dynamic health field, these characteristics of the planning staff will likely be even more important.

Organization for Planning

The manner of organizing for the process of planning for clinical education facilities is of special importance in making the process an efficient and effective one. Good organization is necessary to achieve

⁴Friedman, John, "A Conceptual Model for the Analysis of Planning Behavior," *Administrative Science Quarterly*, Vol. 12, No. 2, September 1967, pp. 233-4.

representation, coordination, and a close tie-in between institutional management and the planning process. The specific form of the organization will, of course, depend upon the particular institution, its characteristics, the approach of its management, and the type and amount of facilities to be planned. While it is not possible to prescribe a "best" organizational arrangement, it is possible to identify some of the most important factors to be considered in deciding upon organizational arrangements and to suggest characteristics which are likely to be needed. This section will attempt to do this.

As has been stated previously, a major premise of this paper is that the process of planning for clinical education facilities is primarily the responsibility of the institution's management and administration, including college administration, hospital administration, and the medical faculty and staff. This process must be a part of the institution's long-range planning. The structuring of the process to provide for broad-based participation of the institution's management, administration, and faculty should result in better plans by facilitating representation, communication, information development, and decision making. It should also enhance interest in the process and acceptance of the plans developed. This close tie with the institution's managerial planning process will also help to make planning for facilities the continuous process that it should be, even though the level of facilities planning activity will vary over time.

Some suggested premises and general considerations for the development of a project organization structure for planning facilities are as follows:

1. Architectural planning and design should be based upon a well-developed "functional program" for the proposed facilities. The functional program should include all relevant elements of the listing shown on pages 178-180, and should be developed by the institution's planners.

2. The development of the functional program should include the documentation of and interaction with institutional long-range plans and program plans. This would include coordination with general campus planning.

3. Coordination with, and possibly strong participation in, regional planning may be needed, especially in regard to patient-care programs.

4. Planning for clinical education facilities should include elements of financial planning, operational planning, and staffing. It should also include the coordination of program development with construction and planning for occupancy.

5. Many special staff projects will be needed during the planning process, e.g., special studies, projections, comparison of alternatives, cost analyses, and systems planning and design.

6. One of the critical questions in the planning and design of facilities will be the balance between capital costs and operating costs.

7. Architectural planning and design will, of course, be the dominant activity during certain phases of the process. The architect should also be included in many other phases of the process leading up to architectural planning and design.

8. The creative aspects of the process should be emphasized.

Ideas and plans for improvement should be promoted, with special emphasis on those having significant implications for facilities. This might include a critical review of improvements, developments, and designs at other institutions.

9. The project activity involved in planning for clinical education facilities requires a significant amount of management activity, including organizing, directing, controlling, scheduling, motivating, planning, staffing, innovating, and representing. The amount and importance of this activity seem to require at least one person devoting a substantial amount, if not all, of his time to project management. Other personnel on the planning team, e.g., systems engineers, architects, hospital administrators, and departmental representatives, should work at the direction of and within the framework established by the project manager.

10. Most of the functions in the clinical facilities will directly involve the school of medicine; however, there will be significant involvement of other schools of the institution which must be considered.

11. Hospital administration and nursing should be heavily involved in the planning for hospital and clinic facilities.

12. The facilities planning project should make use of existing organizational units and arrangements to the largest extent possible consistent with the requirements of effective and efficient planning.

In community hospital planning, the planning team usually consists of representatives of the trustees, hospital administration, medical staff, architects, engineers, and consultants. Reportedly, the

hospital administrator is usually the central and key figure. The role of the consultant usually depends upon the experience, talents, and desires of the administrator; i.e., the consultant is selected to complement the administrator's capabilities.

Organizational arrangements for planning clinical education facilities will probably vary from those of community hospitals for several reasons; e.g., the teaching hospital is a part of a larger institution; the planning objectives derive more directly from the schools than the hospital itself or the local area; the role and status of the medical staff are different; many "experts" are available within the organization; and, developmental planning and the inside-out approach are more prominent. In planning clinical education facilities there will probably be a need for several planning committee and for a full-time professional planning staff. The hospital administrator may not be the project manager or coordinator, although he will surely be one of the key members of the planning team. There will probably be a need for several different types of consultants to complement internal experience and talents, and to meet the desires of the institution's administration.

The managerial structure of the health-education institution is likely to be relatively thin, with many pressing current problems in addition to the requirements of long-range planning. They may not have the time to do a good job of planning for clinical education facilities without significant help from a planning staff. In addition, many aspects of the planning process can best be performed by staff specialists. Several different types of specialists may be needed. Among those which might be considered are systems engineers, behavioral

scientists, city planners, statisticians, nurses, and hospital administrators. The best make-up of the planning staff for any particular institution will depend upon the planning problems faced by that institution, the managerial approach, and the resources available for planning.

One advantage of establishing a full-time planning staff is that the institution can develop the internal knowledge and skill for further facilities planning, including renovation, modifications, and new facilities, as well as knowledge and skill for other types of planning. This would seem to be a strong advantage in view of the shortage of technical managerial staff personnel in academic and medical institutions. It should not be assumed, however, that an internal planning staff can perform all aspects of the job without the help of outside consultants, just as it would not normally be assumed that an institution's architect could handle the entire job without outside architects.

It is often reported that the work of consultants in this field is disappointing. Be this as it may, it seems that the use of certain types of consultants in a well thought-out manner would be invaluable to the process of planning clinical education facilities. For a review of such things as overall proximity relationships, internal area layout, major equipment selection, and environmental control factors, external consultants may have much to offer. There are consultants who spend full-time in the health facilities field and can therefore bring considerable knowledge and experience to bear on many facilities planning problems. They can complement the work of management, the planning staff, and the architect. Consultants cannot, however, relieve the institution of the

burden of internal planning and managerial decisions; they can only supplement this internal process.

The architect's involvement early in the process of planning for specific facilities can provide several benefits. He can learn much of the background of the institution and its objectives, resources, and constraints. He can contribute to the effectiveness and efficiency of the process of planning for facilities by providing information regarding architectural considerations and constraints such as structural and cost implications. He can provide sketches of various building concepts to assist in developing ideas and performing analyses. He can also help speed up the planning process by providing to the planning team fast feedback of the space, structural, design, and cost implications of various ideas and alternatives which are proposed.

The following sections suggest for illustrative purposes an organizational arrangement which is believed to contain most of the elements and characteristics required in the process of planning for clinical education facilities. It should be noted, however, that the specific structure and elements appropriate for any particular institution will depend upon the conditions existing at that institution, including the administration's desired approach; e.g., in some cases city planners may be needed on the planning staff.

Description of Planning Team Positions and Committees

Project Manager. The project manager would be expected to manage the process of planning for facilities by providing the appropriate organization, leadership, coordination, scheduling, and decision making. This position would seem to require at least one person devoting a

substantial amount, if not all, of his time to project management. The project manager should have broad experience and knowledge in the various aspects of the institution's operations, and should be of sufficient stature to command the respect of administration and faculty. The manager need not be a physician, but, depending upon the form and procedures of the institution's managerial planning process, he may have to work directly with or through a medical faculty representative, e.g., the dean of medicine or his designated representative.

Management Systems Engineers. Management systems engineers would provide staff assistance to the project manager through the use of approaches and methods such as networking and scheduling techniques, systems analysis, survey and sampling techniques, flow charting, economic comparison of alternatives, and systems design. They can also assist in general planning staff work.

Architect. The role of the architect in the planning and design of specific facilities after the functional program has been developed is probably well enough understood to need no further elaboration here. In addition to this role, however, his participation during the development of the functional program would facilitate the timely determination of spatial requirements, design implications, and capital costs so that the planning process can proceed more efficiently. He can also help assure that interim alterations fit the eventual master plan as well as possible.

Programmers and General Staff. In a large facilities planning project one of the earliest requirements is the development of a coordinated and approved description of the planned programs, methods, and

functional patterns. This activity requires extensive coordination with and involvement in institutional and departmental program planning. It requires close consultation with the user organizational units through interviews, meetings, written correspondence, etc. This is a laborious and complex task, and should be performed by a person familiar with the various functions of the institution.

This programming should include the identification of deficiencies in present facilities and operations and suggestions for correcting them. It should serve as a vehicle for general improvement. The result should be the development of a coordinated and approved functional program upon which the facilities development program can be based.

Hospital Administration and Nursing. Since the planning is for hospital and clinic facilities, hospital administration and nursing representatives should assist the project manager and other members of the planning staff in developing ideas, planning systems, generating information and data, and evaluating alternatives, in addition to their involvement in general managerial planning.

Clinical Chairmen's Planning Committee (CCPC). Most of the facility plans will be based upon the program plans of the clinical/academic departments. Although each departmental chairman is responsible for developing managerial and program plans for his department and assisting in planning its facilities, the CCPC would serve as an organizational unit representing the chairmen as a group as required for the facilities planning project. The CCPC would assist in coordinating, directing, and decision making in matters related to program plans involving two or more clinical departments. The CCPC might designate a

subcommittee structure as appropriate for planning.

Hospital General Services Planning Committee. This committee would assist the planning staff in developing plans for hospital supporting services and departments, support systems, and other hospital activities. The primary and permanent members of this committee might consist of the hospital administrator, director of nursing, medical and faculty coordinator, and a systems engineer. Representatives of other functional areas would be called upon as necessary. The plans developed by this committee should be based upon and coordinated with the planning of the clinical, educational, and research programs of the clinical academic departments.

Allied Schools' Planning Committee. It can be anticipated that several schools of the institution, in addition to the school of medicine, will use the clinical facilities to some extent. Examples of such schools include dentistry, nursing, medical technology, radiologic technology, medical illustration, and physical therapy. The Allied Schools' Planning Committee would represent these schools and assist in developing plans for their activity in the clinical facilities. The membership of this committee should constitute an appropriate representation of the schools involved.

Campus Planning and Development. Many aspects of clinical education facilities planning will have to be coordinated with the development of total campus plans for facilities and systems. This might be accomplished by cross-representation on committees or by the official in charge of campus planning assuming a direct role in planning clinical education facilities.

Financial Planning. Obtaining capital and operating funds is an important element of developing plans for facilities. This may involve extensive coordination with State and Federal agencies as well as other sources. The appropriate assignments of responsibilities must be made for both of these elements of financial planning.

Central Planning Committee. The Central Planning Committee might consist of the president, dean, and other top administrative officials as appropriate, as well as advisors and representatives of operational units as desired by the administrative officials. This committee would establish the framework for planning in terms of concepts, policies, goals, and constraints. It would also review the progress and results of the various planning projects, make necessary adjustments, and approve final plans.

Other considerations in developing the organizational arrangements for planning clinical education facilities include the appropriate contacts and coordination with community, regional, and state planning agencies, and arrangements for professional consultants as needed at various points in the planning process.

Figure 4 shows one possible arrangement of these organizational elements.

An organizational arrangement such as that described above might be used to manage the planning project in the following manner:

The Central Planning Committee would, through contact with and representation of the top administrative officers, develop statements of major policies and goals of the institution as they relate to the facilities planning project. These goals and policies would be documented by

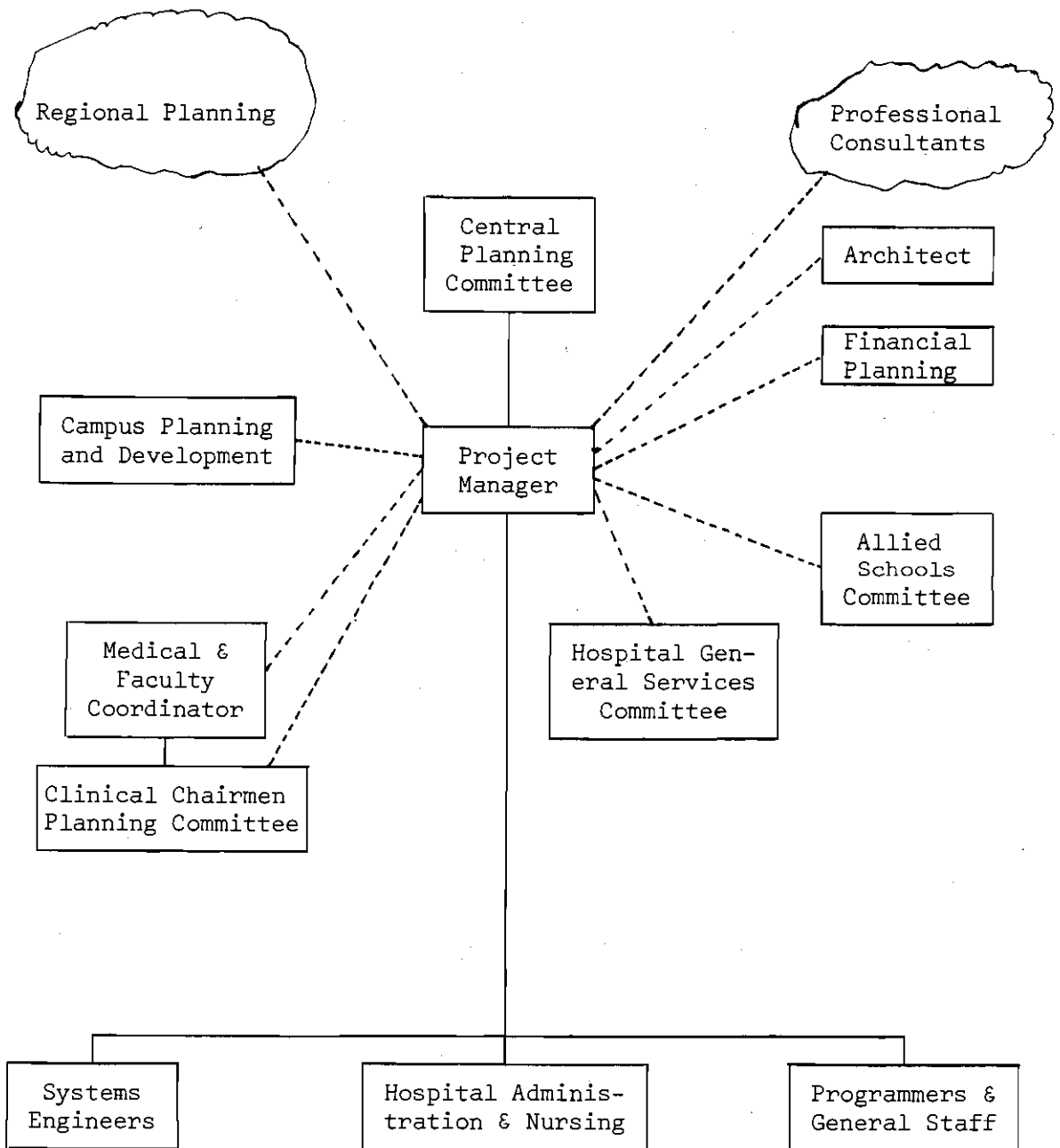


Figure 4. Planning Project Organization Chart

either the administrative officers or the planning staff and distributed to heads of departments and others to be involved in the planning process. The Central Planning Committee would also specify the general scope of the project, including any relevant constraints such as available capital and functional concepts for the buildings.

Within the framework established by the Central Planning Committee, the heads of academic schools and departments would develop policies, goals, and plans for the programs and functions of their organizational units. Much of this planning would be handled within the organizational structure of each department. Coordination and integration of plans with other departments would be accomplished through the committee structure as described below. These committees would assist in collecting and assembling the plans of individual organizational units and assuring that the assemblage represents an "organic" or operational whole.

The clinical departments of the medical school represent the primary organizational units to be served by the facilities. These departments as a group would be represented in the planning process by the Clinical Chairmen's Planning Committee. The CCPC might designate subcommittees to represent various groupings of departments or functional units as the need arises. Decisions involving more than one department would be made by either the appropriate subcommittee or the CCPC as necessary.

The Hospital General Services Planning Committee would be responsible for the development of plans for hospital supporting services and departments, support systems, and other hospital activities. Based upon

and in coordination with the plans of the CCPC, this committee would make tentative planning decisions regarding the matters indicated above as necessary, allowing decisions to be made within the various hospital departments whenever feasible.

The Allied Schools Committee would perform the functions of representation and coordination for the various allied health schools of the institution, and would be responsible for the development of statements regarding the required and desired activity of these schools in the planned facilities. The project manager would see that the appropriate decisions are made regarding the activity of these schools within the medical-clinical service facilities.

Decisions regarding medical or professional practice and those involving academic programs which cannot be resolved at the committee level would be referred to the medical/faculty coordinator for decision or recommendation. His decision or recommendation would be reported to the project manager. Other decisions which cannot be resolved at the committee level would be referred directly to the project manager for resolution.

Parties dissatisfied with decisions or actions at any level which affect them directly could appeal to the individual or committee which is responsible, and, if necessary, to higher organizational levels. They could appeal ultimately to the dean and/or the president.

All organizational units vitally interested in a particular decision would be invited to participate in the discussions, deliberations, and investigations which precede that decision. Any organizational unit whose functions and operations would be significantly affected by the

decision would be considered to have a vital interest. Decisions would be communicated to all interested organizational units on a timely basis to keep them informed of progress and to allow them the opportunity to appeal.

It would be the responsibility of the project manager to see that relevant decisions are made on a timely basis for planning, even if he must make certain tentative decisions himself. The project manager would also assure that the work of the various committees is appropriately coordinated and that adequate communication is accomplished. He would allocate the resources of the planning staff to the various committees and to other activities as appropriate.

The programming of any particular building would be accomplished in a manner similar to that indicated in Figure 10, entitled *Development of Functional and Space Program* on pages 256-257. The staff work involved in obtaining, assembling, coordinating, and documenting this program information would be performed by members of the planning staff and others as designated by the project manager, e.g., departmental managers and administrators.

The functions of the programmers and general staff were described earlier. Systems engineers would be involved in programming as appropriate for special studies, systems design, consultation, etc. The architect would also be involved in programming in order to inject considerations of functional design, cost, and architectural planning.

The project manager would be responsible for providing information on projected needs for capital and operating funds to the appropriate administrative officials so that they can make projections,

identify sources, and obtain commitments for capital funds. The project manager would also coordinate the planning process with the projected schedule of fund availability.

The project manager would work closely with the official in charge of campus planning and development on matters related to total campus plans for facilities and systems. He would also establish appropriate and desirable contacts and relationships with the various community, state, and regional health planning agencies.

Finally, all activities and results of the planning project would be subject to the review and approval of the top administrative official of the institution.

As was mentioned earlier, the specific organizational arrangements appropriate for any particular institution will depend upon the conditions existing at that institution and the administration's desired approach. It should be clear that there are many different ways of organizing and managing such a planning process. There are, however, three basic types of project management to be considered, i.e., the pure, influence, and matrix forms of project management.⁵ These will be briefly discussed in relation to the process of planning for clinical education facilities.

In the "pure" form of project management, the project manager would be given full authority and all necessary resources for the accomplishment of the specific task assigned to him. He would be capable of operating relatively independently of the functional managers of the

⁵Steiner, George A. and William G. Ryan, *Industrial Project Management*, The MacMillan Company, New York, 1968, 243 pp.

institution. Under the "influence" form, the project manager would usually be in a staff capacity to general management. He would have no direct authority, but would act as a monitor and expeditor. The "matrix" form of management involves splintered authority for the project manager. Various personnel from functional areas would be temporarily assigned to him, while at the same time maintaining their direct line of responsibility to their functional supervisors. In addition, the project manager might have a small full-time staff.

Although elements of all three forms of management will probably be involved in the process of planning for clinical education facilities, the first two are not likely to be feasible as the basic form. The pure form does not seem to suit the nature and characteristics of an academic and health care institution. The influence form is not likely to provide the concentrated attention and aggressive leadership required in this particular process. The matrix form of project management seems to be the most suitable.

The matrix form of management probably could not be handled as a part-time responsibility. A full-time project manager should be assigned. He must be the type of person who can accept the challenge of a nonroutine managerial process and organization structure, and who can provide aggressive leadership while promoting creativity. He will not be the master of all required decisions; a broad involvement of the various functional managers is needed. His lines of authority will cross those of the functional managers. The resources required for the project will be shared with the functional areas. The project manager cannot be just

a managerial coordinator; he must understand the technology involved and be able to make technical judgments.

The project manager should have a considerable amount of direct authority in the accomplishment of the planning activity. For example, he should be able to determine the planning activities to be performed, set schedules, and make assignments. One problem that he will surely have in this regard is that the functional managers will resent the time required of them and their personnel in the planning projects.

The project manager should also have control over project planning funds.

In addition to his direct authority, however, influence and indirect authority will be essential to the project manager in accomplishing successful planning.

Special Considerations in Health Facility Planning

Previous sections of this chapter have discussed the process of planning for clinical education facilities without reference to specific aspects of health facilities design. This section will identify and discuss several important aspects of health facilities design which should be explicitly considered in the institution's planning process.

Many of the previously described changes taking place in the health field may affect the design of clinical education facilities. One of these is the implementation of progressive patient care. Under this concept there are usually three levels of care, i.e., intensive, intermediate, and self-care. These levels are defined in a manner which indicates decreasing nursing and medical care requirements. Likewise,

the features required in the facilities for each level are somewhat different. These differences involve utility and equipment requirements--e.g., equipment in intensive care areas require extensive electrical, suction, and oxygen support; layout--e.g., ambulant self-care patients will need recreational space; support systems--e.g., different items and quantities of supplies will be needed in the intensive care unit than in the self-care unit; and staffing--e.g., fewer nursing personnel per patient will be required in self-care than in intensive care. The varying needs in the progressive patient care concept will probably lead to compartmentalized facilities, with each compartment designed to meet the needs of a particular level of care. In some cases separate structures may be justified for one or more of the levels of care. For these reasons it is important that program plans indicate expectations regarding numbers and types of patients in the various levels of care.

The trend towards shorter lengths of hospital stay is another factor which could have a significant impact on facility requirements. Some of the reasons for this trend stem from the rapidly increasing cost of hospitalization, but others are primarily medical in origin. For example, in many cases early ambulation is felt to be good for the patient, therefore shorter periods of hospitalization are possible. Assuming that the same relative mix of types of cases will occur in a given hospital and that the level of occupancy will remain the same, then with a shorter hospital stay more clinical supporting services (e.g., x-ray, laboratory, surgery, and physical therapy) must be provided within a given time period. This type of change tends to

invalidate existing rules-of-thumb and planning ratios for supporting services. Investigations will be required to determine better planning information. The requirement that the same or increased supporting services for a patient be provided in a shorter period of time will also place heavier demands upon the communication, logistical, and scheduling systems of the hospital. New and improved systems may have to be designed.

Health facilities planning must anticipate the use of new and improved equipment and managerial support systems. Examples of these are computers and "management information systems," integrated communication systems, automatic material handling and distribution equipment, and sophisticated medical equipment such as auto-analyzers and electronic patient-monitoring. The architect should know early in his design process which of these will be used, since he will have to incorporate specially designed areas for certain equipment, provisions for utility lines, and increased utility capacity. Decisions on these matters will also affect staffing, traffic, and material flow, all of which the architect must consider in facilities design. Examples in other hospital areas are not difficult to suggest, e.g., convenience food systems.

The dramatically increasing costs of health care today are causing a general questioning of many aspects of the health system. These higher costs may eventually change the pattern of hospitalization, i.e. the types and numbers of patients hospitalized, as significantly as hospitalization insurance has in the past. Such a shift in utilization patterns would have significant effects on facilities requirements. Another effect of rising costs is increasing pressure for improved

operational efficiency. Some of the possibilities for improved efficiency are found in automatic equipment, electronic data processing, and different staffing patterns. Facility design must accommodate these types of changes.

Facility design itself, especially internal layout, is a good area for innovations to improve efficiency. Potential returns from the substitution of capital for labor seem exceptionally good in view of the fact that labor cost usually make up 60-70 per cent of hospital operating expenses, and since $1\frac{1}{2}$ - $2\frac{1}{2}$ years of operating costs normally equal the construction cost of the facility.

The relative locations of various functions and areas within the facility is another factor to be considered by the planning team. These decisions cannot be left exclusively to the architect since many of the relevant criteria are derived from the objectives of the various organizational units and from other technical and operational considerations on which the architect may not be the best judge. One such criterion in planning clinical education facilities is educational effectiveness. Examples of facility implications in this connection might include study areas convenient to nursing units and clinics, work areas and arrangements which facilitate and encourage contact with other students, and a nursing unit design which will accommodate the teaching process without interfering with patient care.

There are many advantages to designs which provide a close relationship between teaching, research, and service areas. The general reason for seeking such a design is that in the clinical areas these three functions are operationally intermingled and overlapping. A more

specific reason is to conserve the time and resources of the clinical faculty. Most of the clinical faculty are involved in all three functions; therefore, lower degrees of "closeness" in the relationships of facilities for these functions may cause more waste of faculty time and effort in travel, coordination, scheduling, and slack time.

Other important proximity relationships involve the patient care process. For example, certain types of patients require frequent use of x-ray and other supporting services. Close proximity to these services reduces inconvenience and travel time. Other types of patients need to be close to certain facilities and equipment which might be needed urgently; e.g., an obstetrical patient may need to go to the operating suite on short notice. Some proximity relationships are derived from the need for certain types of staff to be close to patients, e.g., nurses and on-call doctors. The requirements for these types of proximity, however, are changing with design innovations and new systems such as nurse-servers, baths in each bedroom, improved audio and visual communication systems, and material handling systems. These changes increase the capacity to effectively and efficiently bring services to the point of use without having the service area in close proximity to the user area.

Another proximity question is whether or not certain service functions should be decentralized so that service areas can be placed adjacent to or within certain major user areas. This question, of course, involves the trade-off of "savings" due to proximity of service area to user area and "costs" attributable to decentralized operations

in the service function. In a large hospital this is a difficult question to answer.

The literature on health facility planning often indicates that one of the most urgent needs is for a clearer definition of user requirements. The specification of user requirements is contained in the function and space program, which is usually prepared by the institution with the assistance of consultants and architects. Ideally, the functional and space program should include all of the elements in the outline shown on pages 178-180 and others as required by the particular situation. It should represent a translation of the managerial and program plans into descriptive and quantitative information required by the architect in developing facility designs and by other planners in developing systems and selecting equipment. It should be based upon well-developed plans for an integrated operational system.

Rules-of-thumb and averages from other experiences and facilities may be useful in preliminary budgetary and space estimates, but they are not likely to be satisfactory as firm planning figures for any particular institution. There are too many factors involved which vary from one institution to another. For example, ratios of supporting service space to beds may not be comparable from one institution to another because of variations in outpatient workload and its consequent demand on supporting services. Some additional problems and other considerations in programming and planning are contained in the following outline:⁶

⁶Sahl, R. J., "Analysis of the Space Requirements of Health Teaching Centers," Presented at the Fifteenth International Hospital Congress, Chicago, 1967, 9 pp.

1. Demand and Wishes

- (a) The collection of the demands and wishes of persons representing the various departments will not result in an organic or economic operation.
- (b) The present knowledge and experience of personnel within the institution alone will not lead to the new concepts required to meet future requirements.
- (c) Obtaining what has previously been demanded or requested frequently becomes a matter of prestige.

2. Adoption of Data

The study of other hospitals and projects is stimulating, but the data obtained in this manner is difficult if not impossible to apply because of differences in local conditions, concepts of teaching, research, and treatment, and variations in organization and technical resources.

3. Problems in the Assessment of Space Requirements

- (a) A rapidly changing technology makes the assessment of space requirements difficult.
- (b) Changes in organizational arrangements, systems, and techniques are difficult to anticipate.
- (c) The rising standards of care and working conditions for the staff are difficult to project.

4. Space Requirements and Classification

- (a) Functional division, especially in medical divisions, is becoming more difficult because of increasing specialization and changing methods of care, demanding new ideas for classification and division.
- (b) Strict and formal functional division does not lead to the best economic and operational solution.
- (c) The assessment of space requirements cannot be treated as a self-contained phase, but rather should be interwoven through the design phase.

5. Space Requirements and Functions

- (a) Function and space can be too closely equated, so that space requirements are overstated because of assumed inflexibility.
- (b) The personnel using the space are often not able to judge dependably its necessity and utilization.
- (c) Mistakes in planning are not sufficiently evaluated and communicated so that others can benefit.

6. Space Requirements and Flexibility
 - (a) The more detailed and specific the programming of space requirements, the greater is the risk of rigidity and inflexibility.
 - (b) Complete flexibility has its cost also, part of which is surplus capacity.
7. Space Requirements and Organization of Operation
 - (a) The assessment and judgment of space requirements affects the determination of future operational system.
 - (b) An organizational concept must be developed along with space requirements. Some of the most important organizational questions involve integration, centralization or decentralization, and concentration.
8. Size and Proportion of Space
 - (a) Thinking primarily in terms of rooms can cause serious programming errors. Operational areas allowing internal flexibility is a better basis.
 - (b) The questions of room sizes and standardization are difficult. In many cases, complaints about inadequate space are actually caused by inappropriate arrangements.
 - (c) Variations of 10-15% probably will not affect the efficiency of a room.

With a field as dynamic and changing as the health field is today, flexibility should be one of the primary criteria in evaluating alternative designs. There are several ways to achieve flexibility. One is to design the structure so that it can be efficiently modified internally to accommodate changing functions. This is difficult to achieve in a hospital because of the nature of the process and of the product, the amount of plumbing and other utilities involved, and other special design requirements. The use of standard sized modules and rooms which would suit several different functions will give some flexibility however.

Another way of achieving increased flexibility is to shorten the planned economic life of the facility so that complete changes can be

made more frequently. The successful application of this approach, however, even if proven to be economical, would probably require changes in attitudes and methods of financing hospital facilities and operations. The agencies providing funds for facilities may not encourage designs requiring significantly higher capital funds over the years even with the promise or hope of decreased operating costs, especially since these same agencies are usually not responsible for providing operating funds.

Some other problem areas in health facility planning are as follows:⁷

- Confusion of primary goals
- Lack of knowledge, quantifiable goals, and operational data
- Lack of good coordination and a decision making body
- Conflict of medical practice and the needs of planning
- Lack of good measures of "need"
- Rapid growth and development
- Newness of planning to many personnel in the health field

With these difficulties, it should be no surprise that examples of good planning are hard to find in the literature.

⁷Sigmond, Robert M., "Health Planning," *Dimensions and Determinants of Health Policy*, The Milbank Memorial Fund Quarterly, Volume XLVI, No. 1, January 1968, Part 2, pp. 91-117.

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CHAPTER VII

AN ANALYSIS OF FACILITIES PLANNING ACTIVITY

Scientific investigation in many fields of study has begun with the identification and classification of the elements of the field. Much of the present investigation has been an attempt to analyze the process of planning for clinical education facilities in order to identify the various activities and decisions involved, describe their characteristics, and classify them according to their characteristics. This chapter will attempt to do this in a different, more concise, and more formal manner. Planning activities will be grouped by type as well as by general time relationships and will be formed into graphical planning networks. Several networks will be formed in order to reflect various aspects of the planning process.

This method of classifying planning activities should be useful in several ways. First, it is expected to be helpful in identifying opportunities to use management science tools and techniques and in understanding the practical conditions which affect their usefulness. Activity networks can also be helpful in the management of the process by increasing understanding and by facilitating communication, scheduling, coordination, assignments, and decision making.

The networks developed in this chapter were chosen to represent some of the most important branches of the "technical" process; they do not reflect the political, creative, and random aspects of the process.

They do not reflect many of the interactions and the recycling which are always present in a planning process. Also, they do not include the details of the architectural design of the building, the planning of individual systems, etc. There are some overlaps among the networks, therefore they have many common elements.

The Relationships of Long-Range/Strategic,
Short-Range/Operational, and Project Planning

For the purposes of illustration and the development of a conceptual framework for describing planning requirements, the activities involved in planning for clinical education facilities can be placed into three categories. These categories and their conceptual relationships are shown in Figure 5.

Strategic planning involves setting objectives, anticipating the future and its implications, and developing the means of accomplishing the objectives under anticipated conditions. Long-range planning involves a period of time long enough so that relatively few factors have to be considered fixed. Because of both the opportunities and the uncertainties involved with a long time period, goals and objectives are usually subject to questioning; thus, long-range planning tends to be strategic in nature.

Examples of long-range strategic decisions related to the process under study are as follows:

- (1) Decisions regarding the types of educational programs, their nature, and their resource requirements.
- (2) The student capacity of each educational program.

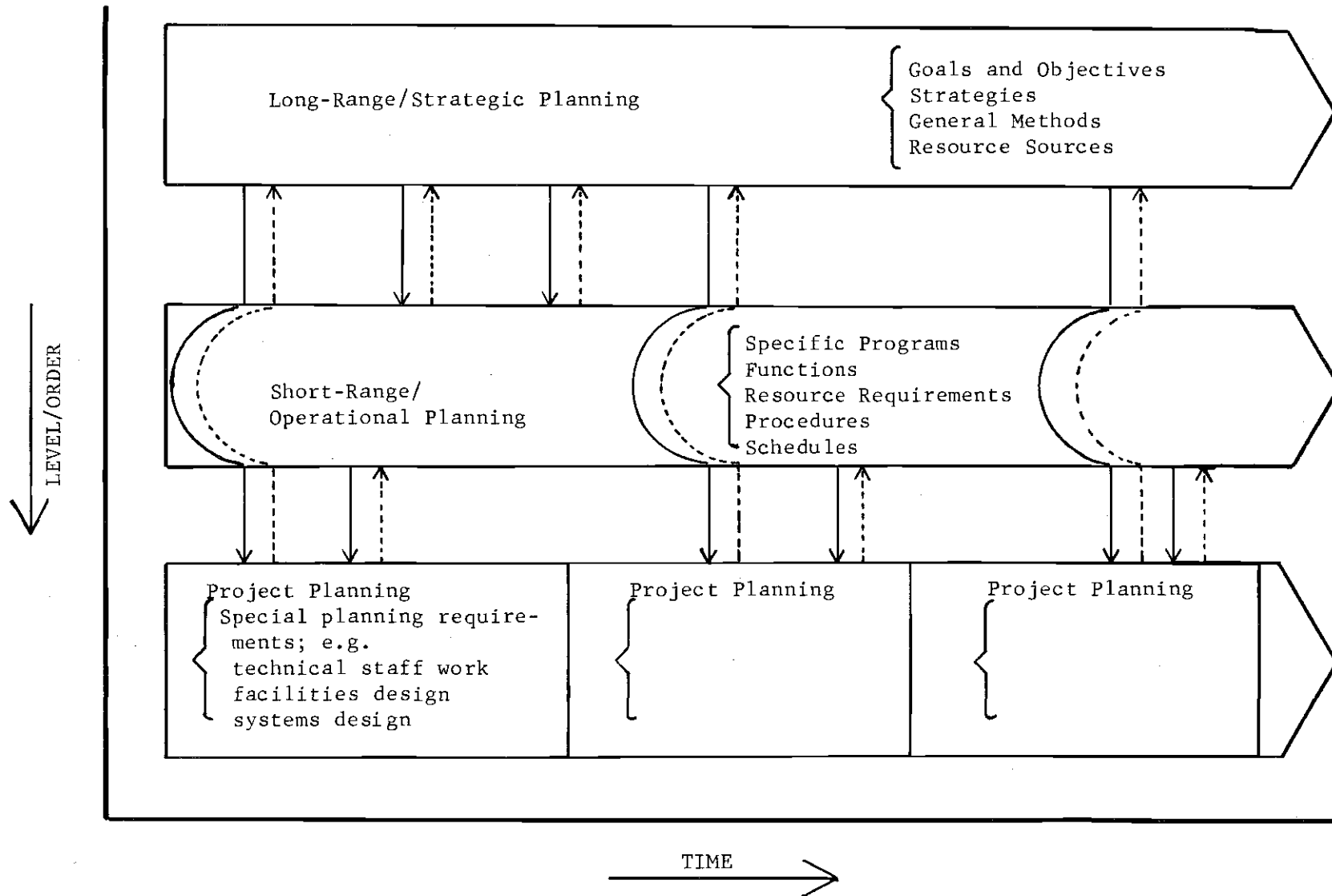


Figure 5. The Time and Level Relationships of Types of Planning

(3) The philosophy of the institution with regard to service programs, e.g., objectives, limitations, priorities, and populations to be served.

(4) Major affiliations with other academic and service institutions.

(5) Sources and amounts of funds.

This level of planning prepares the foundation and the framework for all other levels. Short-range/operational planning should follow and implement the long-range/strategic planning. Project planning should supplement and support the other types. All will be on-going at the same time.

As defined previously, operational planning does not involve the setting of organizational goals, rather it usually assumes a definite future and is directed toward the accomplishment of a specified objective which is relatively definite and specific. Short-range planning involves decisions which will be implemented in the near future and for which the anticipated results are not necessarily long-lasting; i.e., the decisions could be altered without major costs or serious effects on the organization. Short-range planning tends to be operational in nature. Usually, only a few factors are considered variable, while all others are assumed to be fixed.

Short-range/operational planning would normally include the selection of specific programs, methods, resource requirements, and organizational arrangements. For example, decisions required in planning for clinical education facilities would include the following:

(1) Specific academic courses and the capacity of each.

- (2) Clinical programs.
- (3) The patient exposure required for students in various courses.
- (4) Schedules of student activity.
- (5) Operational systems to support academic and clinical programs.

This level of planning will involve more detail, a higher level of sub-optimization and compromise, and a higher technical content than long-range/strategic planning. It will provide feedback to the long-range/strategic level regarding such things as the validity of certain assumptions, changing conditions, inconsistent objectives, opportunities, and resource requirements.

The term "project planning" is used to designate special staff work, systems analysis and design, technical planning, economic analysis, and similar activity related to specific planning questions. These projects would usually be performed by staff specialists. Examples of possible project planning activities are as follows:

- (1) Making forecasts of the size of patient populations.
- (2) Space programming for a particular building.
- (3) The design of a logistical system.
- (4) Architectural design.

This type of activity might support all levels of planning.

The basic elements of the facilities planning network, their general precedence relationships, and their involvement in the three levels of planning described above are shown in Figure 6.

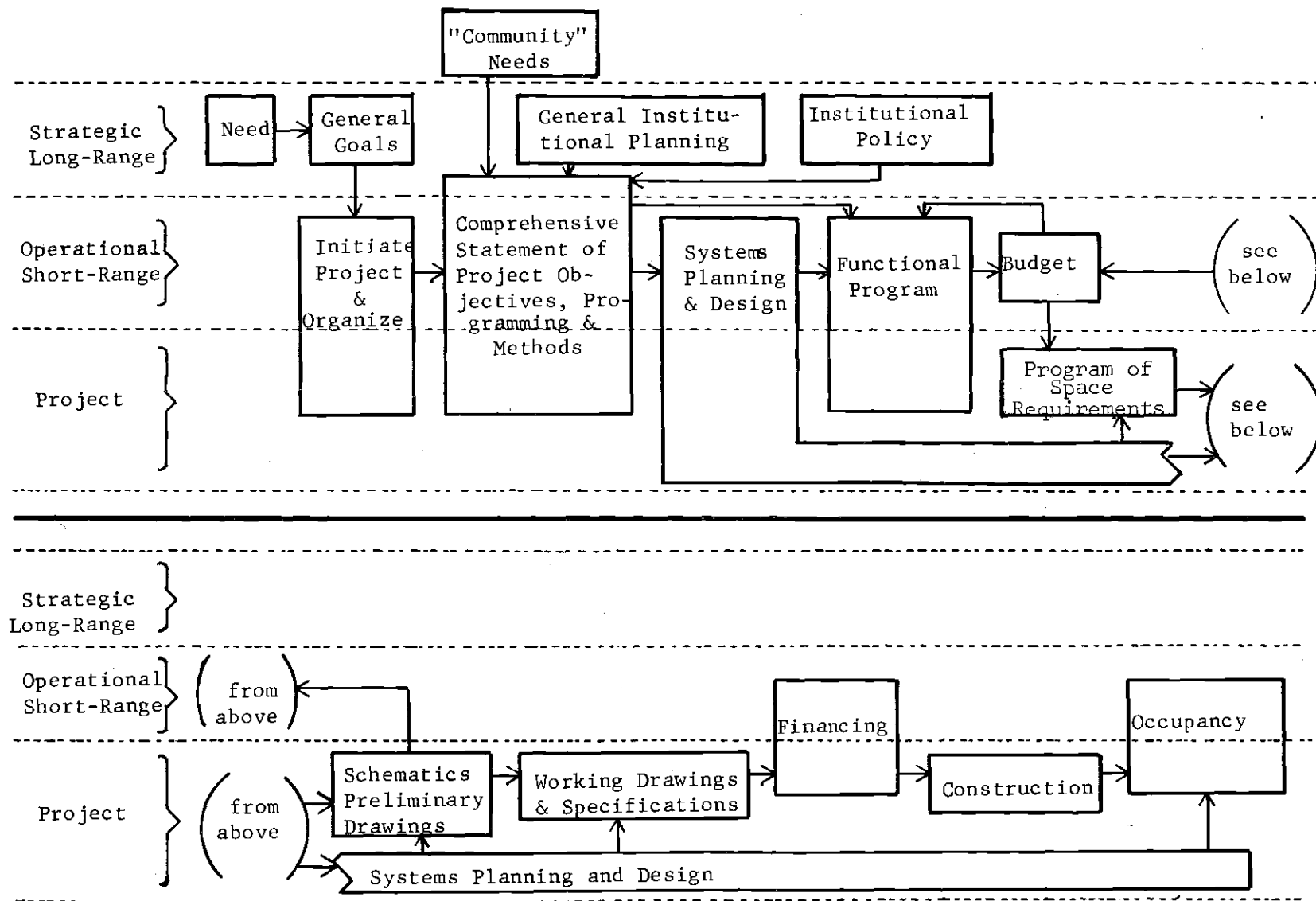


Figure 6. The Relationships of Types of Planning and Elements of Facilities Planning

Overall Facilities Planning Project Network

Figure 7 provides a more comprehensive overview of the facilities planning project activity by identifying the major elements and their general precedence relationships. This graphical network indicates the nature of the process and the framework within which management science applications must fit. It also can be used for project management.

This network, of course, is not the only possible classification of planning activities and is not necessarily the best one for all purposes. Networks, like any other models, should be designed to suit their particular purpose. The precedence relationships shown are not firm, but rather, indicate the general order of activity. In most cases the precedence relationships apply to only certain critical parts of each element, whereas the other parts may be performed in parallel.

Figure 7 indicates the same general order as that of Figure 6, but more detail is included. The process depicted in Figure 7 begins with the development of objectives. The first programs to be planned should be the academic programs since these relate directly to the primary objectives and charges of the academic institution. Other programs must at least fulfill the requirements of facilitating the academic programs, although additional requirements may derive from the related objectives of research and service. The schedule for the construction of phases of the master plan might be developed from a cost/benefit evaluation and from an assessment of fund availability.

Functional programming could begin after the completion of the master plan. Conceptual drawings could begin after basic functional programming but should not be completed before preliminary plans for

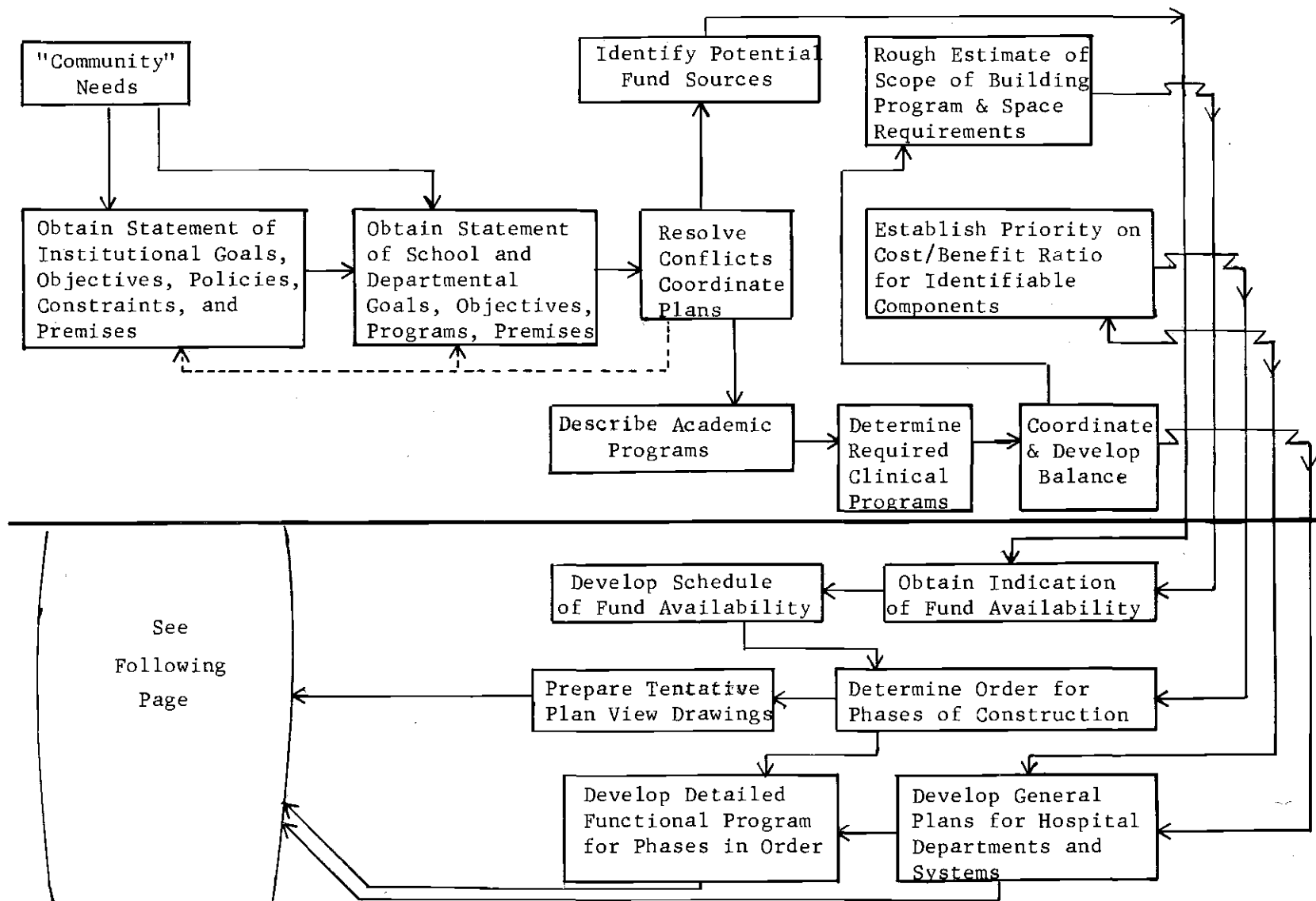


Figure 7. Facilities Planning Project Network

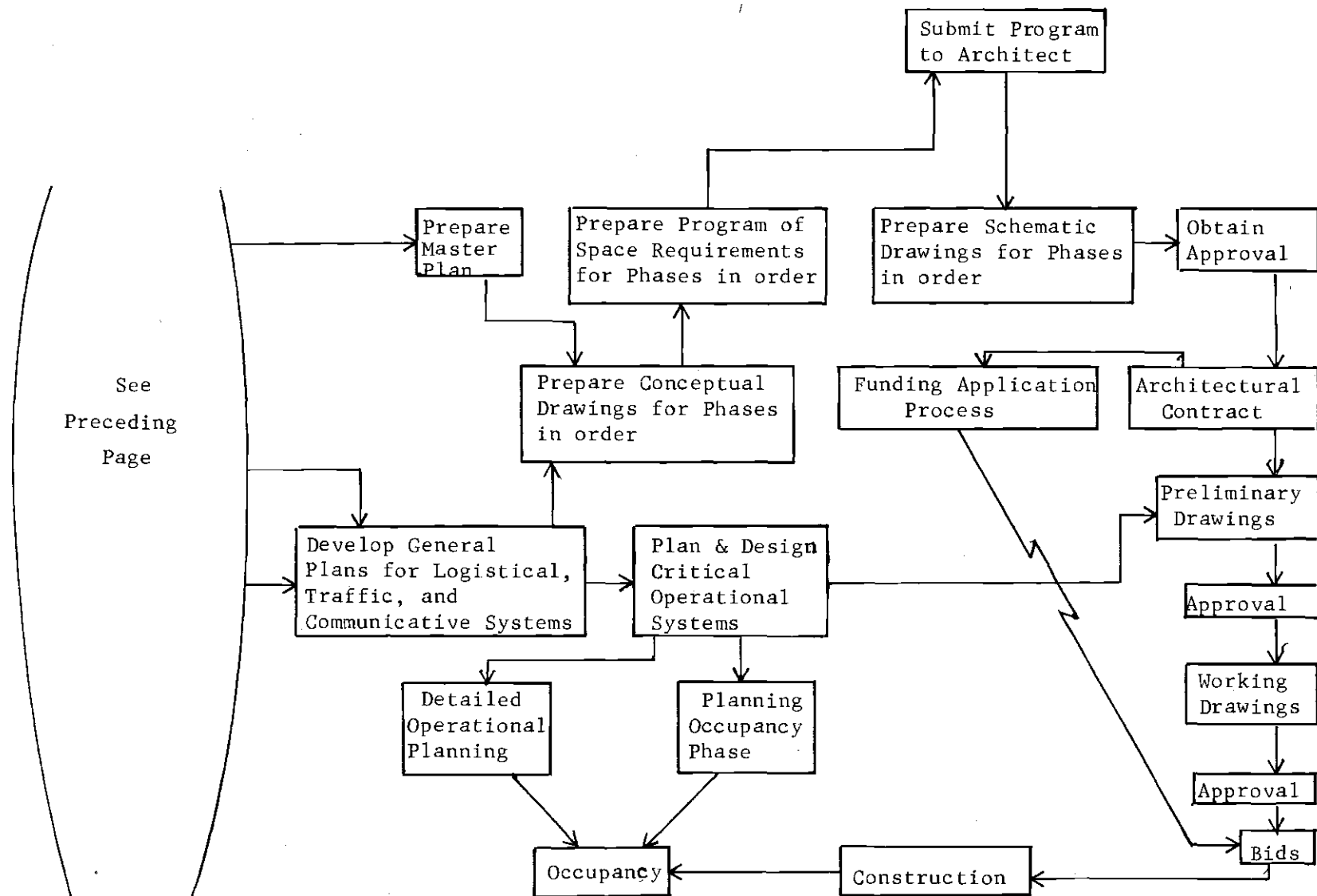


Figure 7. Facilities Planning Project Network (Continued)

the large physical support systems are developed, e.g., logistical, traffic, and communication systems. Many critical aspects of operational systems planning should be completed prior to preliminary drawings. Detailed operational planning can then continue until occupancy.

Projecting Basic Planning Quantities

Figure 8 shows the probable order of determining the types and numbers of students, house staff, faculty, and patients, and it reflects the general relationships of these variables. The specific order and relationships for a given planning project would depend upon the nature of the particular institution, its planning situation, and its priorities and objectives. The calculations for a particular institution would not be expected to be as direct and as linear as implied by this sketch. More complex interactions and loops would probably be involved in the calculation process due to factors such as financial constraints, political considerations, and priorities.

In the simplest situation, the quantity calculated in any one of the blocks of the sketch might be the minimum quantity which would satisfy the minimum requirements of all the input blocks. An example calculation is illustrated in Figure 9.

If there is a constraint on the total number of patients which is less than the total calculated above, then all of the "minimums" obviously cannot be met. In such a case, an optimization technique might be used to compute the number of each type of patient which should be obtained in order to maximize the attainment of objectives. There are several ways in which this allocation might be performed; a quantitative,

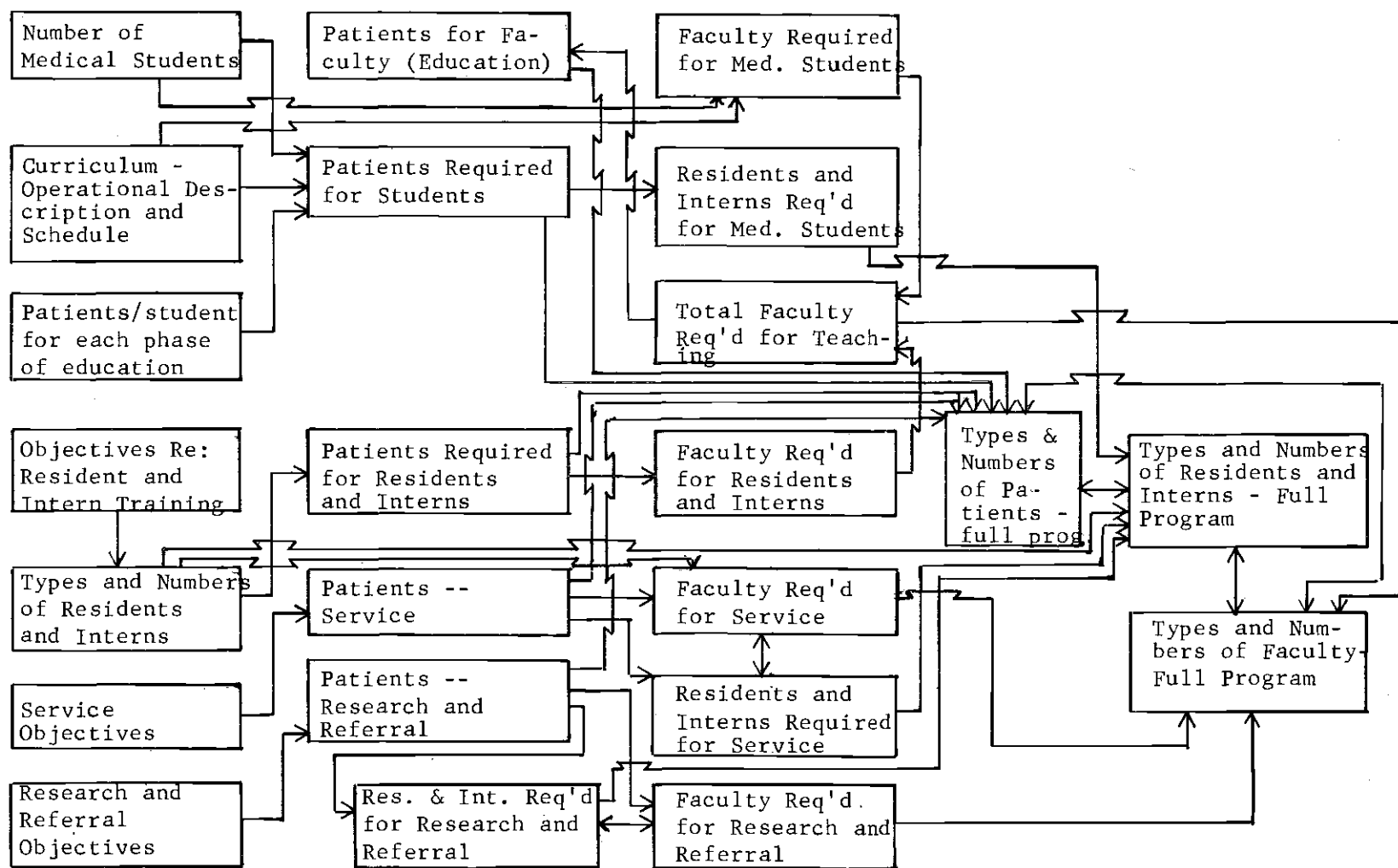
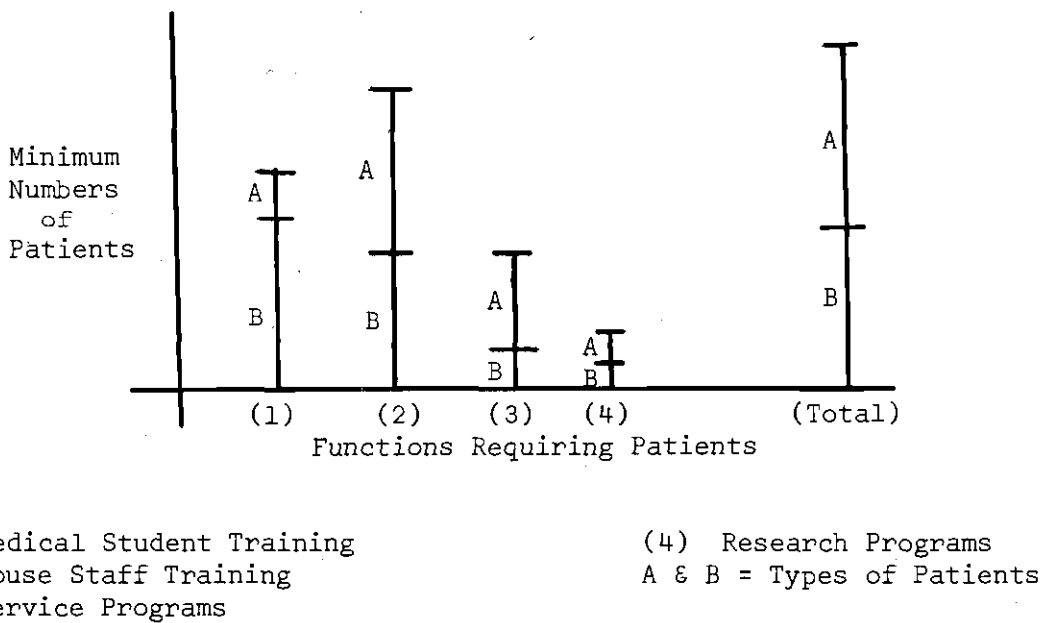


Figure 8. Network for Projecting the Types and Numbers of Students, House Staff, Faculty, and Patients

analytical method is suggested in Chapter VIII. Even without formal analysis, however, a network such as the one shown in Figure 8 would seem to offer a systematic scheme for assessing interactions, developing information, and coordinating decisions in this complex phase of the planning process.



$$\text{Minimum Total Patients} = \text{Max}\{A_1, A_2, A_3, A_4\} + \text{Max}\{B_1, B_2, B_3, B_4\}$$

Figure 9. Example Calculation of Basic Planning Quantities

Development of the Functional and Space Program

The functional and space program consists of a comprehensive statement of institutional planning information, decisions, specifications, and guidelines upon which facility plans should be based. One of its primary purposes is to provide a reference, basis, and framework from which the architect can work in designing the building. As such,

it should include all aspects of managerial, program, and operational planning performed by the institution which would influence the planning and design of the building. Also, it is a useful tool for assembling, documenting, and coordinating the plans of the institution relative to the building program.

Figure 10 outlines the major elements which should be contained in the functional program, and indicates their relative order of development. While relatively comprehensive, this sketch is not intended to be complete in all of its detail; it reflects only major interactions and feedbacks. It serves to illustrate the scope and depth of the required planning activity and should be helpful in making assignments and scheduling planning activity.

In summary, the development of the functional program should begin with an assessment of the institution's environment and the statement of institutional goals and objectives. Next, a master plan should be developed consisting of planned programs, general organizational patterns, an indication of resource availability, and planned levels of operation. From this, utilization and workload projections can be made, and operating policies and procedures can be developed. Organization and staffing decisions can then be based on all preceding information. Finally, general space requirements and specifications are developed.

It will be noted that the development of the functional and space program requires extensive interaction with and dependence upon institutional long-range and managerial planning. Many items to be included should be a product of the continuous managerial planning process.

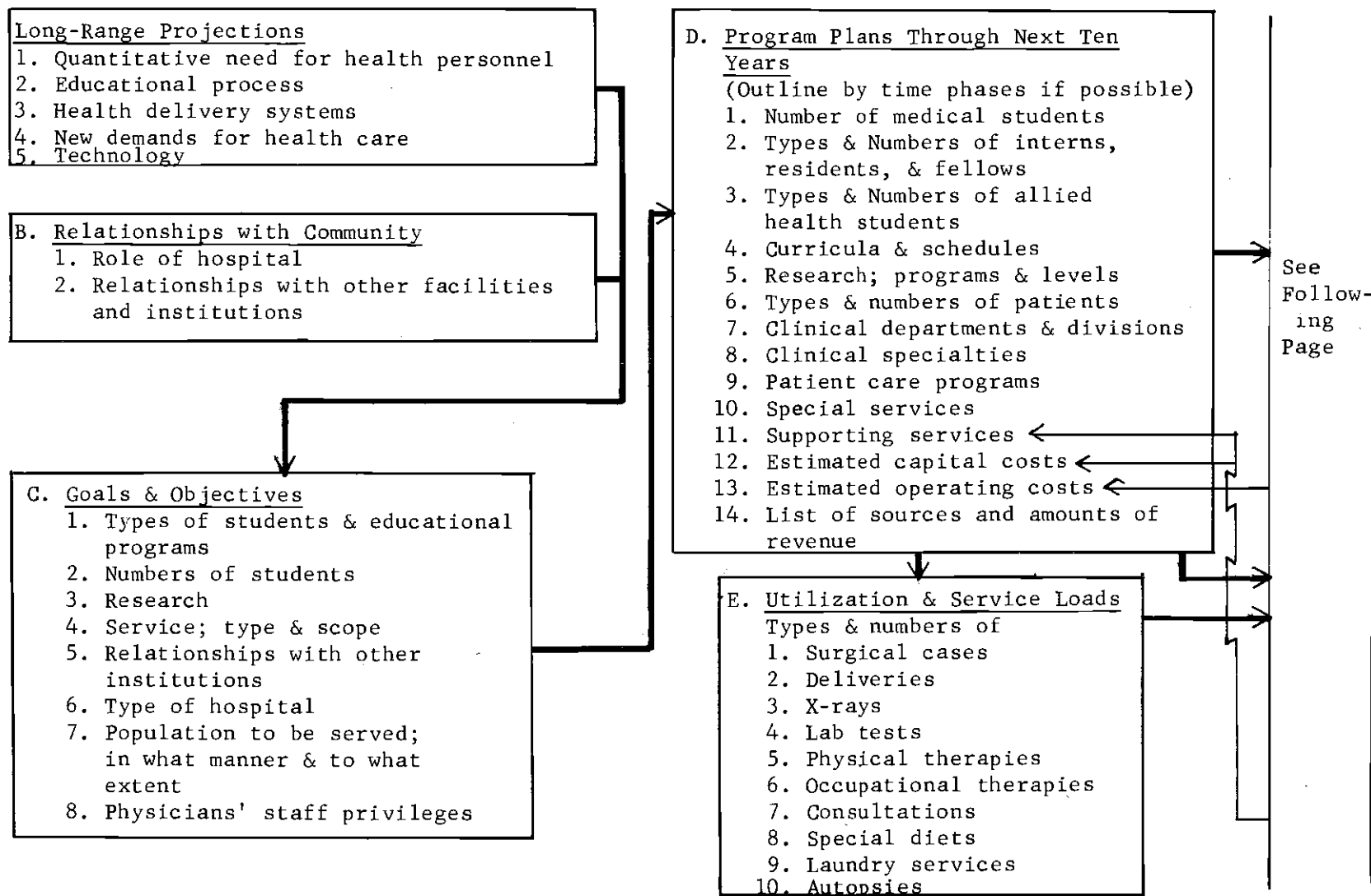


Figure 10. Development of Functional and Space Program

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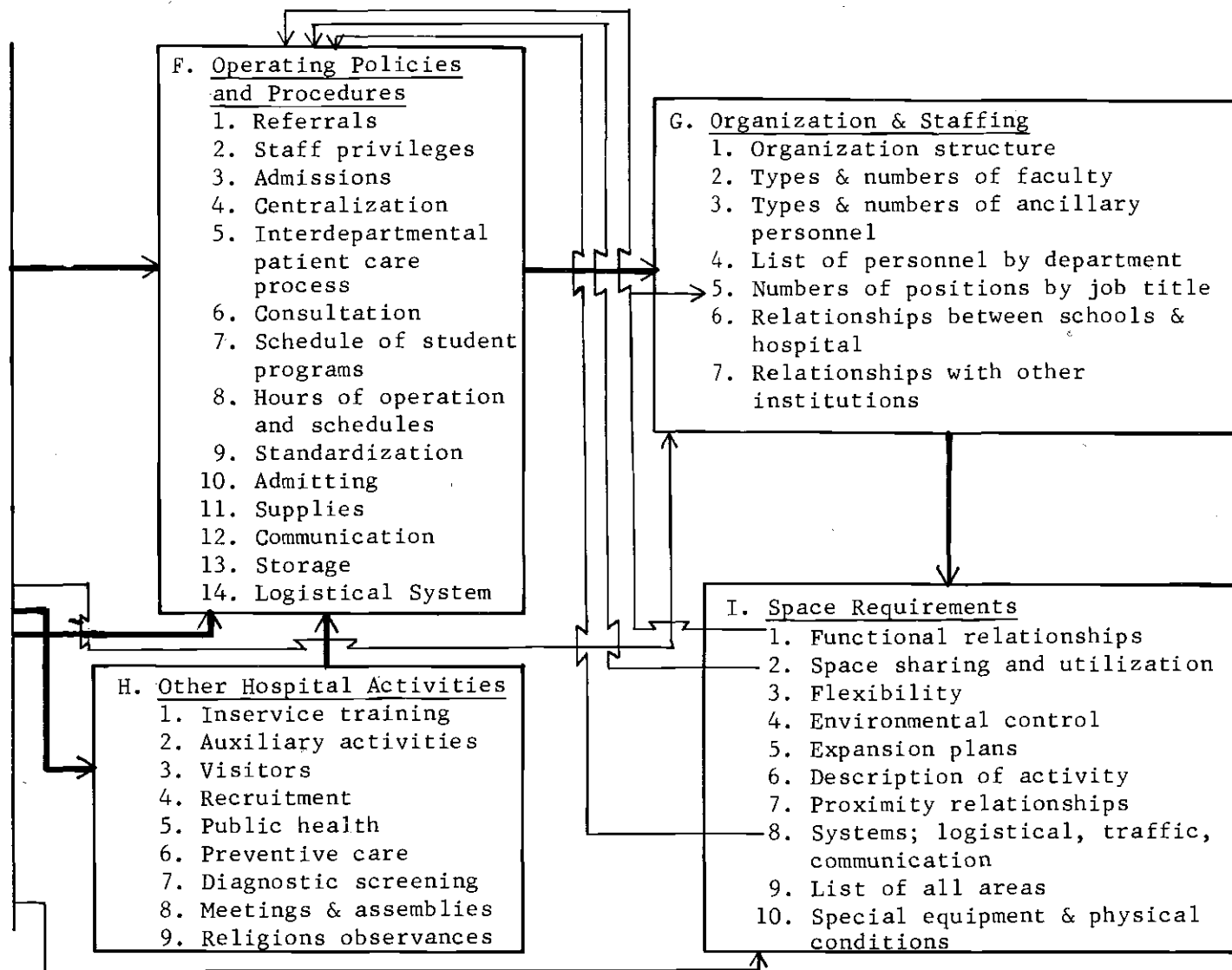


Figure 10. Development of Functional and Space Program (Continued)

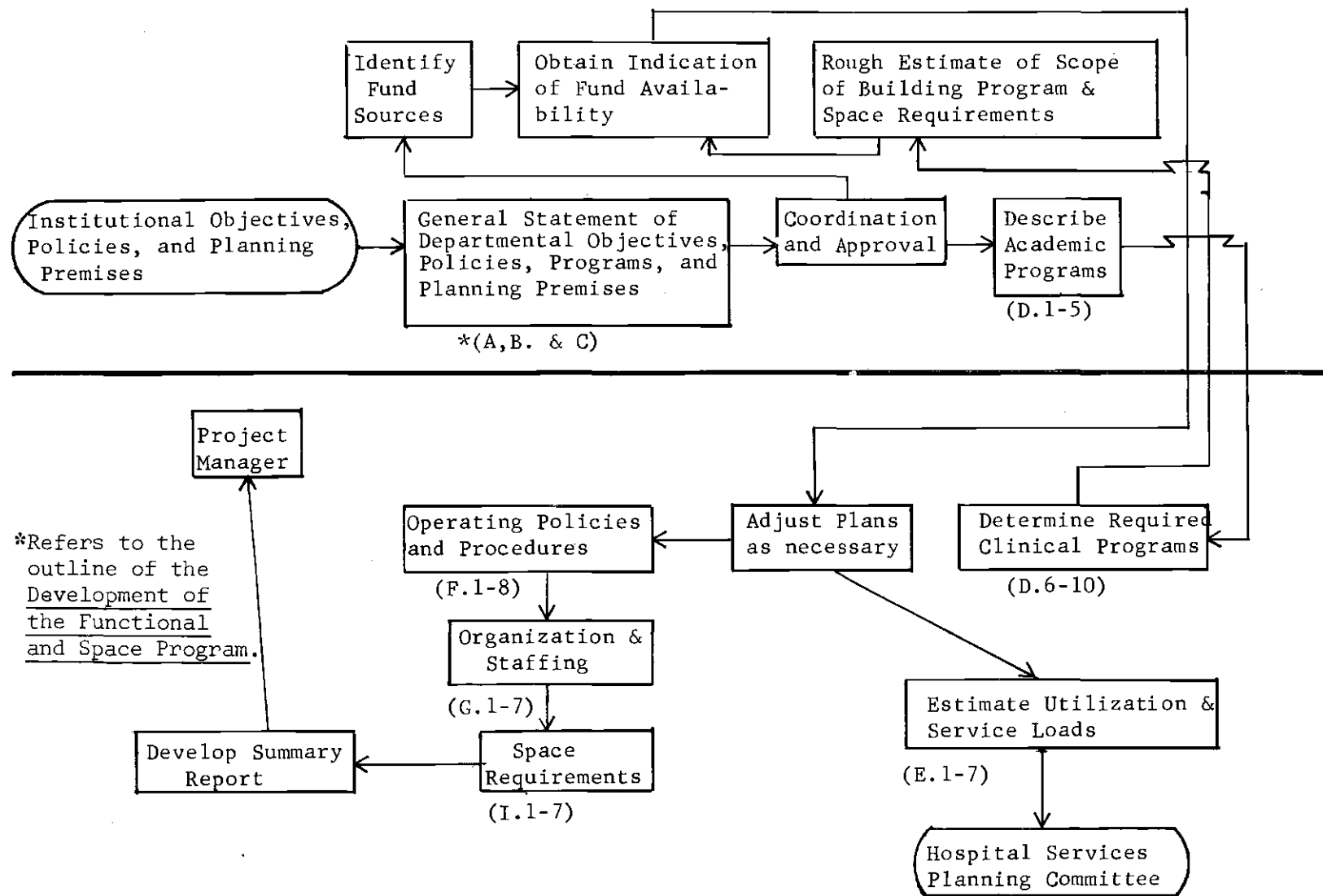


Figure 11. Planning Network for Subcommittees of Clinical Departments

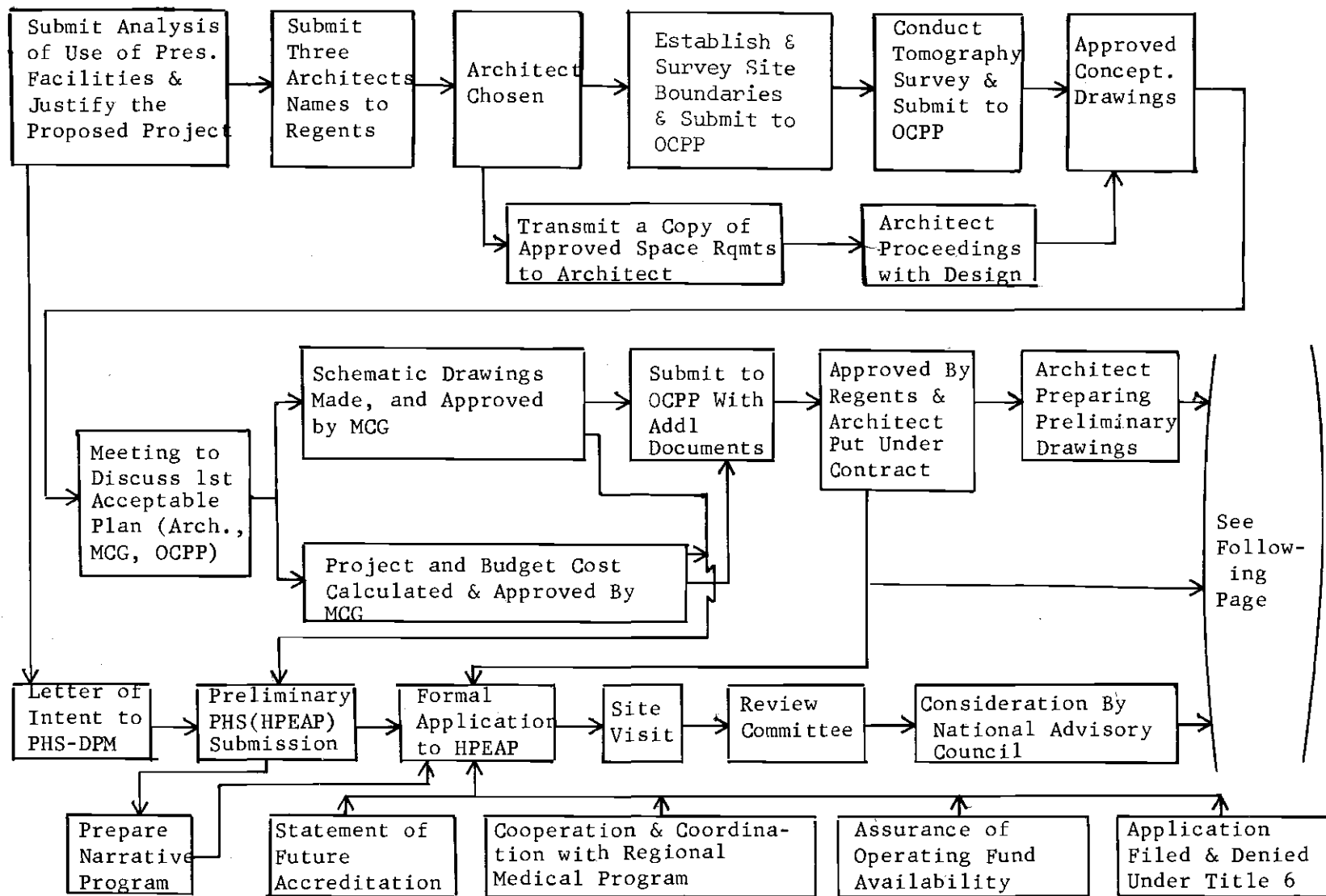


Figure 12. Example Funding Network

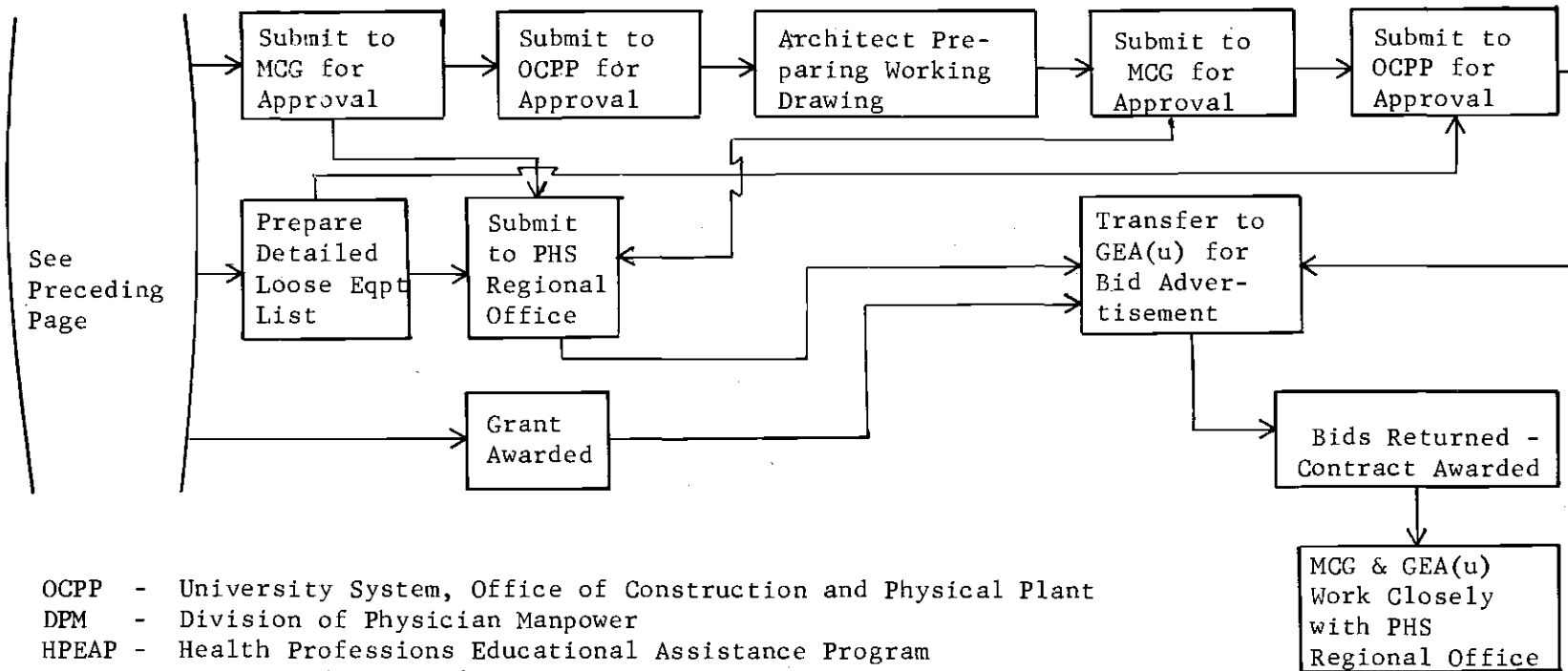


Figure 12. Example Funding Network (Continued)

Planning Network for Clinical Departments

Figure 11 reflects those parts of the "Facilities Planning Project Network" which might be accomplished by the various clinical departments and their planning subcommittees, and it identifies those elements of the functional and space program which would result from the accomplishment of corresponding blocks of the network. This sketch illustrates how the planning elements can be allocated to the various planning committees and to various levels of the organization structure, and shows some of the relationships of their activity with other levels and planning groups. It can be used as a guide for subcommittee planning activity.

Funding Network

Figure 12 portrays the funding process required in the case where two particular funding agencies are involved, i.e., the University System of Georgia and the Health Professions Educational Assistance Program of the U. S. Department of Health, Education and Welfare. This network contains the major elements of this important aspect of facilities planning and their relationships with other phases of the planning process.

It is important that planning for fund acquisition begin early in the process since the possible funding schedules may constrain construction plans and therefore may establish the time and quantity framework for the entire planning project. Also, where funds are being obtained from outside, independent sources, these sources are likely to have regulations, constraints, objectives, requirements, and desires which will influence facility plans and therefore should be considered early in the planning process.

It will be noted that the architect may play a key role in the funding process. Not only might he be expected to be familiar with the various funding procedures and requirements, he also prepares many of the application documents.

The architect must perform a considerable amount of work prior to the establishment of the contract under which his fee is paid. For example, he prepares schematics prior to being placed under contract.

The interaction of the funding process with the managerial planning process should be apparent. For example, the many reviews and approvals in the funding process require extensive coordination and parallel activity in order to achieve reasonable timing; sequential development would be both lengthy and risky. Justifications for funding require extensive documentation of managerial and program plans. Schematics and preliminary drawings require major operational systems decisions. The development of the architectural design concept requires coordination with campus planning. And, the formal application to the Federal Government requires coordination regarding accreditation, regional planning, operating funds, affiliations, and program plans.

CHAPTER VIII

THE APPLICATION OF MANAGEMENT SCIENCE

Theoretically, there are no managerial and administrative organizations to which the approaches and techniques of management science do not apply. There are, however, certain characteristics of organizations and their decision making processes which affect the extent to which management science applications are practicable. This chapter will draw upon the descriptive framework established in previous chapters in order to discuss some of the primary considerations regarding the present and potential application of management science in planning for clinical education facilities, and to provide some example applications.

This study has been directed primarily towards functional programming, which represents the interaction of facilities planning and design with general managerial and program planning. Since planning and programming for facilities usually forces specificity in long-range managerial decisions, it may appear that managerial planning is a part of the facilities planning process rather than vice versa. This integration of the two types of planning brings in many complicating factors which tend to limit the practical applicability of management science, e.g., political considerations, intangible factors, the lack of clear operational objectives, and the heavy roles of managerial and professional judgment, creativity, and innovation.

These complicating factors only limit the potential application of management science; they do not eliminate it. The impact which management science may have on any particular process will depend to a large degree upon the management scientists' understanding of the process, their perceptive ability in selecting the problem areas to study, in timing, in the method of their involvement, and in their willingness and ability to make personal and professional adjustments to meet the needs of the planning process. It will also depend upon the understanding and appreciation by the general managers and planners of the techniques of management science, and upon their willingness and ability to adjust the process as necessary to provide the opportunities, time, and resources required by the management scientists in order to make significant contributions.

There are many ways in which management science can contribute to the planning process, at least in theoretical concept. For convenience of discussion the potential applications will be divided into four categories, i.e., decision theory, qualitative models, quantitative models, and industrial and systems engineering.

Decision Theory

In this section, decision theory is taken to mean the theory of quantitatively and rationally selecting the best alternative from among several on the basis of their degrees of objective achievement. Some objectives have natural measures, but many do not. Decision theory attempts to provide methods for obtaining quantitative measures of the degree of achievement for those objectives and alternatives not

possessing natural measures. In many respects quantitative measures provide more information than other types of measures, and, more importantly in the present case, quantitative measures are necessary for most management science techniques.

Utility Theory

Utility theory may be helpful in providing indications of value for factors with no natural measure, and for converting some "natural measures" into a scale which better measures the power to satisfy human wants. An example of the meaning and the use of utility measures is as follows. Man A has \$1,000,000, and Man B has \$10. Both men are offered \$100 to do an unpleasant job. Which man is most likely to accept the job? Most people would agree that Man B is most likely to accept the job since \$100 would probably be more useful to him than to Man A. In other words, the utility of \$100 to B is greater than the utility of \$100 to A.

The Bernoullian Hypothesis states that the utility of money is a linear function of the logarithm of the dollar value, i.e., $u(x) = a \log x + b$. Even though this hypothesis may not always prove to be true, the logarithmic function does succeed in representing a change in the marginal value of money. The two figures below compare the logarithmic transformation of dollar value into utility with the commonly used assignment of utility (or value) proportional to dollar value.¹

¹Starr, Martin Kenneth, *Product Design and Decision Theory*, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963, p. 36.

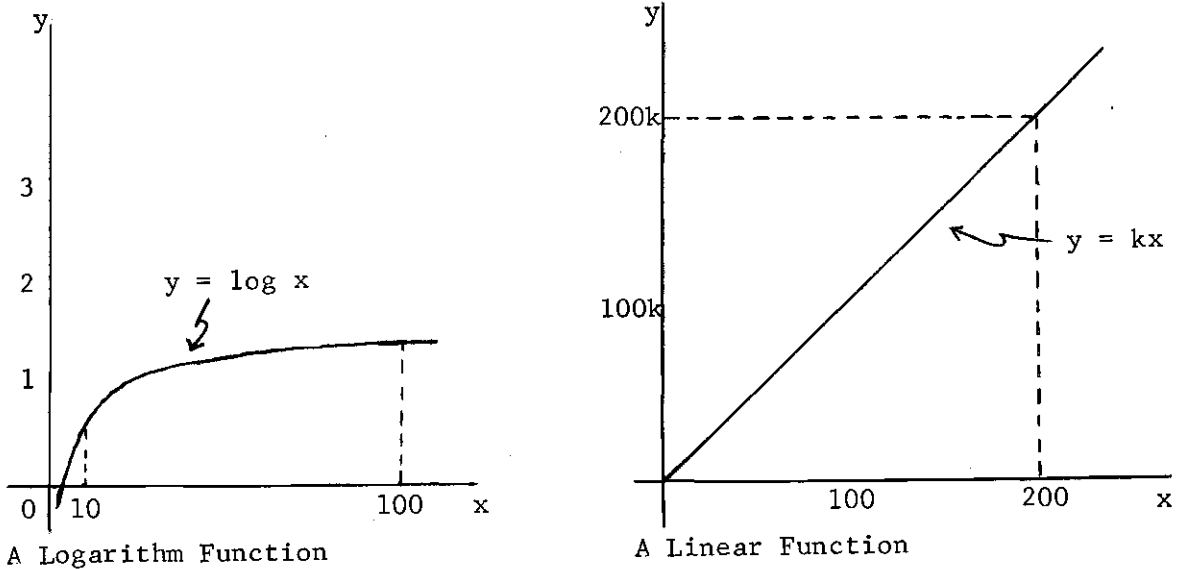


Figure 13. Example Utility Functions

Another possible method of measuring relative utility where there is no natural measure is called the "standard gamble."² To illustrate this method, suppose there are three possible outcomes, and the decision maker has ranked these outcomes in the order A, B, C. We would now ask him to express his preference between,

Choice 1: Getting B certainly.

Choice 2: A situation in which he would get A with probability p , and C with probability $1-p$.

We now vary p . Obviously, if p is 0, then Choice 1 is preferred. If $p = 1$, then Choice 2 is preferred. At some point between 0 and 1 the decision maker has equal preference for Choice 1 and Choice 2. Let us assume that this occurs at $p = 0.9$.

²Miller, David W., and Martin K. Starr, *Executive Decisions and Operations Research*, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963, p. 36.

Since there is no known measure of absolute utility, we assign a scale to suit our purposes. For convenience, assign 0 as the measure of utility for the outcome with the least utility, C, and 1 as the measure for the outcome with the greatest utility, A. Then, at the indifference point,

$$P(A)U_A + P(C)U_C = P(B)U_B$$

$$0.9(1) + 0.1(0) = 1.0 U_B$$

$$0.9 = U_B$$

With these values the decision maker can be guided in his thinking by the spread between the utilities of the outcomes, average utilities, expected values, etc.

Where the attainment of objectives is measured on a continuous scale rather than a two-point (0,1) scale, utility may be better reflected by the assignment of weights to the various factors contributing to the objective. For example, a manufacturer might be trying to select a box to package his product from among several types which are different as to their strength, weight, and cost. To make a selection the decision maker must make trade-offs among these characteristics. In effect, he must weight each factor according to its contribution to value relative to the other factors. The weightings may be subjective.

Various methods might be used to compute or assign the subjective weightings. One method is to measure the critical factors of a group of alternatives and then get the decision maker to furnish his judgment of the overall value of each alternative. It might then be assumed that the sum of the products of the factor measures and their respective subjective weightings will be equal to the overall value of a particular alternative. For example, the equation for the value of one of the alternatives might be as follows:

$$W_1 R_{11} + W_2 R_{12} + W_3 R_{13} + \dots W_i R_{ij} + \text{Error} = V_I$$

where W_i = weighting, R_{ij} = factor measures, and V_I = overall value. With a sufficient number of such evaluations multiple regression procedures could be used to solve for the subjective weightings for each factor. Another method is for one decision maker, or a group of decision makers to make direct assignments of weights to contributing factors.

As an illustration of the potential application of these types of techniques in the facilities planning process, consider the case in which a large number of items of equipment must be evaluated and selected for use in a building. Decision theory applied by computer techniques might be used to reduce the burden on the decision maker in the following way. Suppose there are five factors to be considered in evaluating each item of equipment, i.e.,

1. cost/use
2. reliability
3. patient safety and comfort
4. employee safety
5. employee satisfaction.

It might be assumed that the decision maker's evaluation of each item of equipment can be expressed as some mathematical function of these five factors, e.g.,

$$W_1F_1 + W_2F_2 + W_3F_3 + W_4F_4 + W_5F_5 + E = V,$$

where F_1 = factor 1, W_1 = relative weight of factor 1, and V = the evaluation of the item under consideration. If measures are available or can be developed for each of the factors, the relative weights can be determined by one of the methods mentioned above. If such an equation were developed on the basis of a large sample of a decision maker's evaluations and proven to be a satisfactory predictor of his evaluations, then, with the appropriate factor measures, the remaining items of equipment could be evaluated by a computer through the use of the equation. This selection methodology might reduce the time required of the planners and lead to greater consistency in the decision making process. It should also enable the evaluation of a larger number of alternative items.

There are other potential benefits of this type of approach in addition to that of preventing the decision maker from having to make essentially the same decision over and over. Where a large number of complex and interacting variables must be considered in making a

particular decision, this approach should make the decision process easier and better by breaking one complex decision down into smaller, easier-to-handle decisions. It should also permit increased use of management by exception, since the equations could be applied by computer and lower level personnel. Higher levels of personnel would then have to consider only those decisions which don't fit the pattern of the decision model represented by the equations. Another use of this approach might be to develop objective functions for use in operations research models. This use will be illustrated later.

One possible difficulty with the above approach is that the factor weights may not actually remain constant over the entire range of measures for the factor. To illustrate, there may be a critical level of reliability for a particular item of medical equipment below which the equipment would not be used, whereas variations across other points in the measure of reliability may change the item's "value" very little. This is illustrated in Figure 14.

There will be many decisions in the planning process for which there are no quantitative payoff measures. In such cases, some of the weaker tools of decision theory may be useful, such as ranking and priorities. For example, many decisions will involve patient care, education, and research objectives. In most cases, there will be no good quantitative measures of the degrees of achievement of these objectives. Methods such as ranking furnish limited information by indicating the relative order of utility of the alternatives.

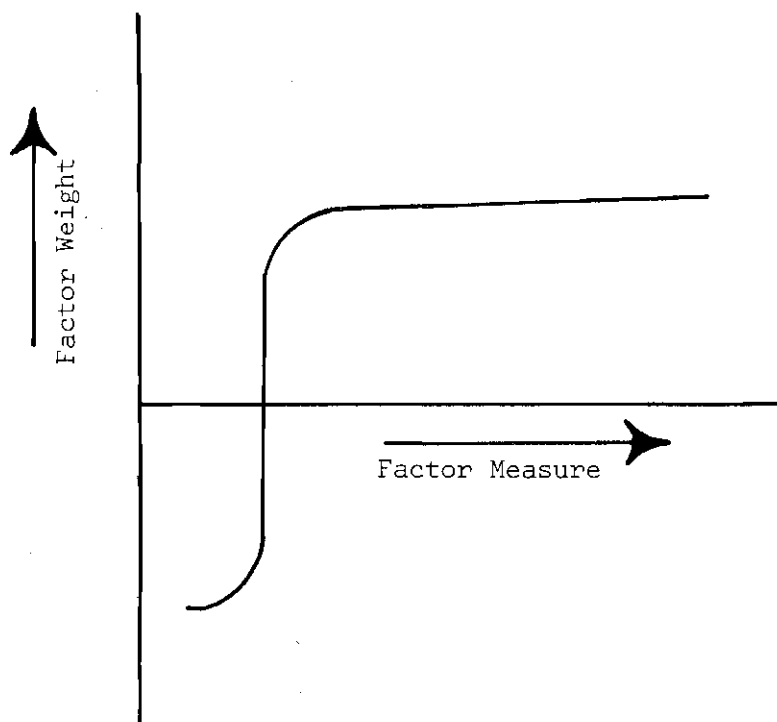


Figure 14. Changes in Factor Weight

In some cases it may be extremely difficult for the decision maker to assign ranks and to use them meaningfully. For example, three alternative Programs--A, B, and C--may have to be evaluated in three dimensions, i.e., patient care, education, and research. A may be preferred to B in terms of patient care, but B may be preferred to A in terms of education and research. C may be preferred to B in terms of education, whereas B is preferred to C in terms of patient care and research, etc. For the decision maker to rank these alternatives in order of preference, he must subjectively determine tradeoffs among the objectives.

Even where rankings and priorities are possible, their value to analysis is limited. For example, the relative difference in value between rank 1 and rank 2 is not necessarily the same as the difference between 2 and 3. Also, there is no "absolute zero" point in such measures. Most of the ordinary arithmetic manipulations of these numbers have no meaning. Since ranks and priorities do not provide information regarding marginal returns, they do not provide an adequate basis for determining analytically an optimal allocation of resources among alternatives. For example, if education is given priority 1, how does one know whether to put all resources into education or to stop putting resources into education at some point and begin allocating them to patient care and research?

Risk and Uncertainty

Risk and uncertainty are other conditions dealt with in decision theory. A planner will usually have to consider different possible states of nature when selecting a strategy. If he knows the probability of occurrence of the possible states of nature, then it is said that he is making a decision under risk. If he does not know the probabilities, then it is said that he is making a decision under uncertainty. Consider the following matrix of strategies (S_1, S_2), states of nature (N_1, N_2, N_3), probabilities of states of nature (P_1, P_2, P_3), and value outcomes (X_{ij}):

| | P_1 | P_2 | P_3 | |
|-------|----------|----------|----------|--------|
| | N_1 | N_2 | N_3 | |
| S_1 | X_{11} | X_{12} | X_{13} | EV_1 |
| S_2 | X_{21} | X_{22} | X_{23} | EV_2 |

In decision making under risk, the P_j are known, and the expected value of each strategy can be computed as follows:

$$EV_i = (P_1)(X_{i1}) + (P_2)(X_{i2}) + (P_3)(X_{i3}).$$

If the X_{ij} represent the actual values of the outcomes to the decision maker, then the rational choice would be that strategy with the maximum expected value. The maximum expected value would not necessarily be the best choice when the X_{ij} do not represent an absolute measure of "value" or utility, e.g., when X is measured in monetary units, while the utility of money to the decision maker is some non-linear function of dollar value.

To illustrate the possible application of expected value in planning, consider a hypothetical problem in which the medical school is trying to decide whether to add a wing to its teaching hospital to accommodate a particular clinical service which would be beneficial to its educational programs. It is possible that the Veterans Administration will build a hospital adjacent to the medical school which would provide this same clinical service, and which could be used by the medical school for its educational programs. The medical school must

make a decision regarding the addition of its wing now; the VA's decision may not be made until two or three years later. Medical school administrators have decided to evaluate their alternatives in terms of the values of outcomes ten years from now, and have estimated these values in numerical terms. Also, they have been able to estimate the probability that the VA hospital will be available to them. This decision problem can now be expressed as follows:

| | P_1 | P_2 | |
|-------|----------|----------|--------|
| | N_1 | N_2 | |
| S_1 | X_{11} | X_{12} | EV_1 |
| S_2 | X_{21} | X_{22} | EV_2 |

| | .25 | .75 | |
|-------|-------|-------|--------|
| | N_1 | N_2 | |
| S_1 | 10 | 2 | EV_1 |
| S_2 | 0 | 8 | EV_2 |

where,

N_1 = condition of VA hospital not being available

N_2 = condition of VA hospital being available

P_1 = probability of $N_1 = 0.25$

P_2 = probability of $N_2 = 0.75$

S_1 = strategy of building new wing

S_2 = strategy of not building new wing

X_{ij} = value of outcome from strategy S_i under condition N_j

EV_i = expected value of strategy S_i .

The expected values of the strategies are computed as follows:

$$EV_1 = .25(10) + .75(2) = 4.0$$

$$EV_2 = .25(0) + .75(8) = 6.0$$

Therefore, with expected value as the decision criterion, the new wing would not be built.

The decision is made under the condition of uncertainty if no information is available regarding the probabilities of the various states of nature. Under this condition there is no one best criterion for decision, although several might be suggested. One possible criterion, which reflects a pessimistic view, selects the strategy with the best of the worst possible outcomes. This is called the "maximin" criterion. For example, in the decision problem described above, the worst that can happen if S_1 is selected is an outcome with a value of 2, and the worst with S_2 is an outcome of 0; therefore, S_1 would be selected.

The "maximax" criterion suggests the selection of the strategy with the highest possible return; it is the criterion of optimism. This criterion, also, would lead to the selection of S_1 in the problem above.

Under the "regret" criterion the decision maker attempts to minimize the possible regret, i.e., the difference between the value of the strategy chosen and the best strategy for a particular state of nature. To apply this criterion to the problem described above the payoff matrix is converted to a regret matrix, as follows:

| | N_1 | N_2 |
|-------|-------|-------|
| S_1 | 0 | 6 |
| S_2 | 10 | 0 |

A "minimax" criterion is applied to the regret matrix by selecting the strategy with the lowest of the maximum possible regrets. In this case, the maximum possible regret is 6 for S_1 and 10 for S_2 . Therefore, S_1 would again be selected.

The final criterion to be described is the "Laplace" criterion. Under uncertainty, this criterion assumes the probabilities for the states of nature to be equal. (There are many philosophical arguments against this criterion which will not be discussed here.) The expected value of each strategy is then computed using equal probabilities, and the strategy with the highest expected value is selected. In the above problem, $EV_1 = 6$ and $EV_2 = 4$; therefore, S_1 is again chosen.

It should be pointed out that the various criteria under uncertainty do not usually lead to the same decision, as happened to be the case above.

Game theory, which involves decision making in competition with a rational opponent, does not seem applicable to the planning process being considered; therefore, it will not be discussed in this paper. Decision making under assumed certainty where quantitative measures of achievement are available will be discussed in a later section.

Qualitative Models

Most thinking about reality starts with qualitative models and subsequently develops to a point where quantitative models can be used. The earlier qualitative model must reach a certain degree of correspondence to reality before the quantitative step can be taken. Many sciences that deal with particularly complex kinds of reality are still at the stage of developing suitable qualitative models. And these qualitative models can afford a great deal of insight into the complexities of their subject matter.³

This section will discuss some types of qualitative models which are expected to be useful, or even vital, in the planning process being studied. They should be useful not only in analyzing and understanding the process, and as a first step towards the application of management science to this problem area, but also in managing and performing the planning.

In this chapter the word "model" is used as meaning a representation of some real object, action, process, or system, which attempts to reflect some aspect of it. There are many different types of qualitative models, some of which will be mentioned here.

Scale Model

A scale model is a reduced dimension physical representation of certain selected elements of a physical entity or system. For example, a scale model of a building could be a three-dimensional mock-up or a two-dimensional drawing. Such models are used to present a scale which enhances visual perception and facilitates more efficient communication, analysis, and evaluation.

³Miller and Starr, *op. cit.*, p. 141.

Flow Diagrams

Flow diagrams serve the same purpose as scale models in representing the movement of units, the relationships of components of a system, logical thought processes, and activity relationships.

Although any model might be considered a *simulation model*, this term has come to mean logical models which portray the operations of the components of a system and their interactions over time. Computers are usually used for computational efficiency and effectiveness, although not all simulation models are computer models. Simulation models are especially effective for complex systems analysis.

Classification

Classification schemes place things, activities, or concepts in categories according to their characteristics. Classification includes the process of definition. This is one of the most primitive forms of modeling, and in many cases forms the foundation for study, analysis, and understanding of a particular field. It provides a framework within which to perform other types of analyses and to which results of study can be referred.

Outlines and Charts

Outlines and charts, which might be considered a form of classification, organize information on a particular subject in a format which portrays certain characteristics of that subject. This type of model pervades all levels of analysis.

Verbal Models

Verbal models, i.e., the narrative form, offer the most flexible, universal, and yet most inefficient and least precise of all models. This is probably the first type of modeling required in any new area of study, and may be critical to successful modeling of other types and to the evaluation and implementation of the results of studies. The importance of verbal modeling is often not reflected in the amount and quality of effort given to it, especially by technical personnel.

The various functions of qualitative models are illustrated in the brief descriptions above. They include recording, classifying, and conveying information, identifying pertinent variables, and indicating the qualitative relationships among variables. Most importantly, they serve to establish a theoretical and conceptual structure for understanding the subject area, making decisions, and identifying areas for further investigation.

Qualitative modeling is needed at this stage of the analysis and improvement of the process of planning for clinical education facilities. The elements of planning involved, their characteristics, and their relationships must be identified. A validated concept for and an understanding of the total process must be developed. This type of modeling should precede attempts at esoteric, specialized, quantitative management science research and applications so that they will be more relevant, realistic, and productive. For these reasons, a large portion of this paper is devoted to qualitative models.

Quantitative Models

It has been said that man does not really understand a thing until he can measure it and assign numbers to it. While this may be true, it is also true that life forces activities to proceed whether or not there is real understanding. Planning for clinical education facilities involves many areas which are not very well understood. There are, however, several kinds of decisions which must be made in this process for which quantitative methods are appropriate. Even though most of the quantitative methods will provide only partial answers, or answers which must be evaluated within the context of other non-quantitative factors, they can be useful in the decision process and can provide insights which might not otherwise be obtained.

A few hypothetical examples of potential applications of quantitative management science models in the process of planning for clinical education facilities are provided in this section. Some of their limitations and other considerations regarding their use will be discussed later.

The Assignment Problem

The structure of this type of problem involves the assignment of a group of "jobs" which must be performed simultaneously to a group of alternative "locations" or processes of differing efficiencies in a manner which will minimize costs (or maximize returns). For example, suppose we have four jobs, any one of which may be assigned to any one of four locations, with no more than one job at any location. To put the problem in the context of clinical facilities planning, assume that the

jobs represent four out-patient clinics which must be assigned to four different locations in a building being planned, with the present worth of operating costs and differential building costs (in thousands of dollars) of each alternative assignment as shown below:

| Locations | | | | |
|-----------|-----|-----|-----|-----|
| Clinic | 1 | 2 | 3 | 4 |
| A | 70 | 80 | 75 | 90 |
| B | 90 | 100 | 95 | 105 |
| C | 120 | 130 | 135 | 140 |
| D | 130 | 135 | 140 | 150 |

It should be apparent with some reflection that a simple approach such as assigning each job in sequence to the location giving its minimum cost will not necessarily result in the minimum total cost. For example, the assignment of Clinic A to location 1 would be \$5,000 cheaper than its next lowest cost alternative, location 3; but this would eliminate the possibility of assigning Clinic C to location 1 which would cost \$10,000 less than its next lowest cost alternative. There are many such "trade-offs" which are difficult, if not impossible, to identify and evaluate by inspection. Although in a small cost matrix all possible alternative assignments could be enumerated and evaluated, this would be impossible in larger problems, e.g., a 10 x 10 matrix.

An algorithm for finding the optimal assignment is available, as follows:⁴

1. Determine the job-opportunity-cost matrix by subtracting the smallest entry in each column of the cost matrix from every entry in the column.
2. Determine the total-opportunity-cost matrix by subtracting the smallest entry in each row of the job-opportunity-cost matrix from each entry in the row.
3. Determine the smallest number of rows and/or columns which include all the zeroes in the total-opportunity-cost matrix. If this number equals the total number of rows the problem is solved and it is only necessary to select the assignments from among the zeroes.
4. If the problem is not solved in step 3 then find the smallest entry in the matrix which is not on one of the rows and/or columns containing zeroes. Add this entry to the entry at every intersection of a row and a column containing zeroes. Subtract it from every entry in the matrix which is not on one of the rows and/or columns containing zeroes.
5. Repeat the process until step 3 shows that a solution has been obtained.

The simple example above is solved with the formation of the first total-opportunity-cost matrix, as follows:

Step 1 (Job-Opportunity-Cost)

| Locations | | | | |
|-----------|----|----|----|----|
| Job | 1 | 2 | 3 | 4 |
| A | 0 | 0 | 0 | 0 |
| B | 20 | 20 | 20 | 15 |
| C | 50 | 50 | 60 | 50 |
| D | 60 | 55 | 65 | 60 |

Step 2 (Total-Opportunity-Cost)

| Locations | | | | |
|-----------|---|---|----|---|
| Job | 1 | 2 | 3 | 4 |
| A | 0 | 0 | 0 | 0 |
| B | 5 | 5 | 5 | 0 |
| C | 0 | 0 | 10 | 0 |
| D | 5 | 0 | 10 | 5 |

⁴*Ibid.*, p. 288.

From the above, we see that an optimal solution is the assignment of clinic A to location 3, clinic B to location 4, clinic C to location 1, and clinic D to location 2.

The Transportation Problem

The problem of deciding how to get the required amounts of material to a number of locations from a number of sources of specific capacities with a minimum of transportation cost is called the transportation problem. Although transportation is the traditional framework for this problem formulation, its structure may fit other situations. For example, suppose we are attempting to find the lowest cost scheme for exposing medical students to patients with defined degrees of illness within specific clinical departments. And suppose there is a certain total number of exposure weeks required for each degree of illness, with given maximum exposure weeks within each department, and differing costs per exposure week to the hospital for each degree of illness within each department. This problem can be summarized in the following table, which contains hypothetical numbers:

| Degree of Illness | CLINICAL DEPARTMENTS | | | | Required Weeks per Degree of Illness |
|------------------------------|-----------------------------------|----|----|----|--------------------------------------|
| | A | B | C | D | |
| | Cost per Exposure Week (In \$100) | | | | |
| 1 | 4 | 5 | 3 | 5 | 20 |
| 2 | 5 | 6 | 4 | 5 | 20 |
| 3 | 6 | 7 | 5 | 7 | 10 |
| Maximum Exposure Weeks/Dept. | 20 | 20 | 12 | 12 | |

The solution algorithm to be followed requires that the sum of the requirements equals the sum of the capacities.⁵ To meet this requirement in the above example we add a "dummy" degree of illness with a requirement of 14 weeks of exposure, and assign a very high cost so that the "dummy" will not influence the resultant solution, as follows:

| Degree of Illness | CLINICAL DEPARTMENTS | | | | Required Weeks per Degree of Illness |
|------------------------------|-----------------------------------|----|----|----|--------------------------------------|
| | A | B | C | D | |
| | Cost per Exposure Week (In \$100) | | | | |
| 1 | 4 | 5 | 3 | 5 | 20 |
| 2 | 5 | 6 | 4 | 5 | 20 |
| 3 | 6 | 7 | 5 | 7 | 10 |
| 4D | 10 | 10 | 10 | 10 | 14 |
| Maximum Exposure Weeks/Dept. | 20 | 20 | 12 | 12 | 64 |

The next step is to find a feasible solution as a starting point. The feasible solution shown below was found by the Northwest Corner Method; i.e., starting with the upper left-hand block, assign the maximum amounts possible to each adjacent block within the capacity and requirements constraints. This method resulted in five blocks with actual assignments. Since the algorithm requires seven variables in the solution, "false" assignments (ϵ) were made to two other blocks selected arbitrarily. These false assignments are taken to be so small

⁵See, for example, Sasieni, Maurice, *et al.*, *Operations Research: methods and problems*, John Wiley & Sons, Inc., New York, 1959, pp. 194-218.

that they do not affect total cost. Assignments are shown in the upper right-hand corner of each block.

| Degree of Illness | CLINICAL DEPARTMENTS | | | | Required Weeks per Degree of Illness |
|----------------------------|--|--|--|---|--------------------------------------|
| | A | B | C | D | |
| | Cost per Exposure Week (In \$100) | | | | |
| 1 | 4 20 | 5 | 3 € | 5 | 20 |
| 2 | 5 | 6 20 | 4 € | 5 | 20 |
| 3 | 6 | 7 | 5 10 | 7 | 10 |
| 4D | 10 | 10 | 10 2 | 10 12 | 14 |
| Maximum Exposure Wks/Dept. | 20 | 20 | 12 | 12 | 64 |

The modified cost (i.e., the cost including the dummy location) for this solution is given as follows:

$$\text{Cost} = 20(4) + 20(6) + 10(5) + 2(10) + 12(10) = 390$$

The search for an improved solution is performed by examining the opportunity costs for those blocks to which no assignment has been made. We look at the incremental cost (or savings) of assigning one unit to any empty block and making the necessary adjustments in other block assignments. If such an assignment would reduce total cost, then we reallocate assignments to bring that block into the solution.

A convenient method of evaluating opportunity costs for each block is to assign arbitrary "row costs" and "column costs" such that

the row and column costs for each block in the solution add up to the actual unit cost of that block. The opportunity cost for each non-solution (empty) block is then computed by subtracting the sum of the row and column costs for that block from its actual unit cost. A negative result indicates that the total cost can be reduced by making an assignment to that block. The block with the most attractive opportunity cost can be selected to enter the solution next.

The row costs, column costs, and opportunity cost evaluations for the above matrix are shown below. Opportunity cost evaluations are shown in the upper left-hand corner of each block.

| CLINICAL DEPARTMENTS | | | | | | | | | | |
|----------------------------|-----------------------------------|------|----|----|----|------|----|----|--------------------------------------|----|
| Degree of Illness | A | | B | | C | | D | | Required Weeks per Degree of Illness | |
| | Cost per Exposure Week (In \$100) | | | | | | | | | |
| 1 | 4 | 20 0 | 5 | | 3 | € 2 | 5 | | 20 | 3 |
| 2 | 0 | 5 | 6 | 20 | 4 | € 1 | 5 | | 20 | 4 |
| 3 | 0 | 6 | 0 | 7 | 5 | 10 2 | 7 | | 10 | 5 |
| 4D | -1 | 10 | -2 | 10 | 10 | 2 | 10 | 12 | 14 | 10 |
| Maximum Exposure Wks/Dept. | 20 | | 20 | | 12 | | 12 | | 64 | |
| | | | | | | | | | row costs | |
| | | | | | | | | | column costs | |
| | 1 | | 2 | | 0 | | 0 | | | |

Based upon the above evaluations, block 4D-B is selected for entry into the solution. The maximum amount possible within the constraints of the problem is reallocated to this block. The resultant assignments and the evaluation of this solution are shown below:

| | A | B | C | D | | |
|----|---------------|---------------|---------------|--------------|----|---|
| 1 | 4 <u>20</u> 0 | 5 | 3 <u>€</u> 0 | 5 | 20 | 3 |
| 2 | 0 5 | 6 <u>18</u> | 4 <u>2</u> 0 | 6 | 20 | 4 |
| 3 | 0 6 | 0 7 | 5 <u>10</u> 0 | 7 | 10 | 5 |
| 4D | <u>1</u> 10 | 10 <u>2</u> 2 | 10 | 10 <u>12</u> | 14 | 8 |
| | 20 | 20 | 12 | 12 | | |
| | 1 | 2 | 0 | 2 | | |

$$\text{Modified Cost} = 80 + 108 + 8 + 50 + 20 + 120 = 386$$

Since there are no negative opportunity costs in the above evaluation, an optimal solution has been found. This solution is summarized below. The total cost of this solution is given by,

$$\text{Cost} = 20(4) + 18(6) + 2(4) + 10(5) = 246.$$

Optimal Solution:

| Degree of Illness | CLINICAL DEPARTMENTS | | | | Required Weeks per Degree of Illness |
|---------------------------|----------------------|----|----|---|--------------------------------------|
| | A | B | C | D | |
| 1 | 20 | | | | 20 |
| 2 | | 18 | 2 | | 20 |
| 3 | | | 10 | | 10 |
| Max. Exposure Weeks/Dept. | 20 | 18 | 12 | 0 | |

A Transportation Problem with Lower Bounds on Variables

A more realistic version of this problem might be one in which some of the variables have lower bounds representing minimum exposure requirements of the curriculum. For example, the problem presented above might have constraints on some of the variables as shown in the cost matrix below:

| CLINICAL DEPARTMENTS | | | | | |
|---------------------------|-----------------------------------|----|----|----|--------------------------------------|
| Degree of Illness | A | B | C | D | Required Weeks per Degree of Illness |
| | Cost per Exposure Week (In \$100) | | | | |
| 1 | ≥4 | ≥4 | ≥4 | 5 | 20 |
| | 4 | 5 | 3 | | |
| 2 | ≥6 | ≥6 | 4 | ≥4 | 20 |
| | 5 | 6 | | 5 | |
| 3 | 6 | 7 | ≥4 | 7 | 10 |
| | | | 5 | | |
| Max. Exposure Weeks/Dept. | 20 | 20 | 12 | 12 | |

The solution methodology shown below involves a change of variables to eliminate the constraints so that the algorithm used on the previous problem can be used again. For example, we set $X_{1A} = \bar{X}_{1A} + 4$. The resulting equations are shown below:

$$(\bar{X}_{1A} + 4) + (\bar{X}_{1B} + 4) + (\bar{X}_{1C} + 4) + X_{1D} = 20; \bar{X}_{1A} + \bar{X}_{1B} + \bar{X}_{1C} + \bar{X}_{1D} = 8$$

$$(\bar{X}_{2A} + 6) + (\bar{X}_{2B} + 6) + X_{2C} + (\bar{X}_{2D} + 4) = 20; \bar{X}_{2A} + \bar{X}_{2B} + X_{2C} + \bar{X}_{2D} = 4$$

$$X_{3A} + X_{3B} + (\bar{X}_{3C} + 4) + X_{3D} = 10; X_{3A} + X_{3B} + \bar{X}_{3C} + X_{3D} = 6$$

$$(\bar{X}_{1A} + 4) + (\bar{X}_{2A} + 6) + X_{3A} = 20; \bar{X}_{1A} + \bar{X}_{2A} + X_{3A} = 10$$

$$(\bar{X}_{1B}+4) + (\bar{X}_{2B}+6) + X_{3B} = 20; \bar{X}_{1B} + \bar{X}_{2B} + X_{3B} = 10$$

$$(\bar{X}_{1C}+4) + X_{2C} + (\bar{X}_{3C}+4) = 12; \bar{X}_{1C} + X_{2C} + \bar{X}_{3C} = 4$$

$$X_{1D} + (\bar{X}_{2D}+4) + X_{3D} = 12; X_{1D} + \bar{X}_{2D} = X_{3D} = 8$$

Now the matrix can be rewritten with the redefined variables:

| | A | B | C | D | |
|----|----|----|----|----|----|
| 1 | 4 | 5 | 3 | 5 | 8 |
| 2 | 5 | 6 | 4 | 5 | 4 |
| 3 | 6 | 7 | 5 | 7 | 6 |
| 4D | 10 | 10 | 10 | 10 | 14 |
| | 10 | 10 | 4 | 8 | |

Application of the solution algorithm produces the following iterations:

| | A | | B | | C | | D | | | | |
|----|--------------|---------------|----|--------------|---------------|----|---------------|----|--------------|----|---|
| 1 | 4 | <div>80</div> | 5 | | <div>-2</div> | 3 | <div>0</div> | 5 | 8 | -5 | |
| 2 | 5 | <div>2</div> | 6 | <div>2</div> | <div>-2</div> | 4 | <div>-1</div> | 5 | 4 | -4 | |
| 3 | <div>0</div> | 6 | 7 | <div>6</div> | <div>-2</div> | 5 | <div>0</div> | 7 | 6 | -3 | |
| 4D | <div>1</div> | 10 | 10 | <div>2</div> | | 10 | <div>4</div> | 10 | <div>8</div> | 14 | 0 |
| | 10 | | 10 | | 4 | | 8 | | | | |
| | 9 | | 10 | | 10 | | 10 | | | | |

$$\text{Modified Cost} = 32 + 10 + 12 + 42 + 20 + 40 + 80 = 236$$

| | A | B | C | D | | |
|----|--------------|---------------|--------------|-------------|----|----|
| 1 | 4 <u>8</u> 0 | 5 <u>0</u> | 3 <u>0</u> | 5 <u>0</u> | 8 | -5 |
| 2 | 5 <u>2</u> | 6 <u>2</u> 0 | 4 <u>-1</u> | 5 <u>0</u> | 4 | -4 |
| 3 | <u>0</u> 6 | 7 <u>2</u> | 5 <u>4</u> 0 | 7 <u>0</u> | 6 | -3 |
| 4D | <u>1</u> 10 | 10 <u>6</u> 2 | 10 <u>2</u> | 10 <u>8</u> | 14 | 0 |
| | 10 | 10 | 4 | 8 | | |
| | 9 | 10 | 8 | 10 | | |

$$\text{Modified Cost} = 32 + 10 + 12 + 14 + 20 + 60 + 80 = 228$$

| | A | B | C | D | | |
|----|--------------|---------------|--------------|-------------|----|----|
| 1 | 4 <u>8</u> 1 | 5 <u>1</u> | 3 <u>1</u> | 5 <u>1</u> | 8 | -6 |
| 2 | 5 <u>2</u> 1 | 6 <u>1</u> | 4 <u>1</u> | 5 <u>2</u> | 4 | -5 |
| 3 | <u>-1</u> 6 | 7 <u>2</u> | 5 <u>4</u> 0 | 7 <u>0</u> | 6 | -3 |
| 4D | <u>0</u> 10 | 10 <u>8</u> 2 | 10 <u>2</u> | 10 <u>6</u> | 14 | 0 |
| | 10 | 10 | 4 | 8 | | |
| | 10 | 10 | 8 | 10 | | |

$$\text{Modified Cost} = 32 + 10 + 10 + 14 + 20 + 80 + 60 = 226$$

| | A | B | C | D | | |
|----|--------------|----------------|--------------|-------------|----|----|
| 1 | 4 <u>8</u> 1 | 5 <u>0</u> | 3 <u>1</u> | 5 <u>1</u> | 8 | -6 |
| 2 | 5 <u>6</u> 1 | 6 <u>0</u> | 4 <u>0</u> | 5 <u>4</u> | 4 | -5 |
| 3 | 6 <u>2</u> 1 | 7 <u>1</u> | 5 <u>4</u> 1 | 7 <u>1</u> | 6 | -4 |
| 4D | <u>0</u> 10 | 10 <u>10</u> 1 | 10 <u>1</u> | 10 <u>4</u> | 14 | 0 |
| | 10 | 10 | 4 | 8 | | |
| | 10 | 10 | 9 | 10 | | |

$$\text{Modified Cost} = 32 + 20 + 12 + 20 + 100 + 40 = 224$$

The evaluation of the last matrix above shows that an optimal solution has been found. By converting back to the original variables, the optimal allocation is seen to be the following:

| Degree of Illness | CLINICAL DEPARTMENTS | | | | Required Weeks per Degree of Illness |
|---------------------------|-----------------------------------|----|----|----|--------------------------------------|
| | A | B | C | D | |
| | Cost per exposure week (in \$100) | | | | |
| 1 | 412 | 54 | 34 | 5 | 20 |
| 2 | 56 | 66 | 4 | 58 | 20 |
| 3 | 62 | 7 | 58 | 7 | 10 |
| Max. Exposure Weeks/Dept. | 20 | 10 | 12 | 8 | 50 |

$$\text{Real Cost} = 48 + 20 + 12 + 30 + 36 + 40 + 12 + 40 = 338$$

The optimal exposure weeks for each degree of illness for each department can be read from this matrix.

Linear Programming

The two examples above are actually special cases of the general linear programming model,

$$\text{Maximize } z = \underline{Cx}, \quad \text{where } \underline{Ax} = b \text{ and } x \geq 0.$$

Now let us consider an example of the general linear programming (LP) problem.

Suppose that in planning for a new teaching hospital one of the critical decisions is the mix of minimal care, intermediate care, and

intensive care beds on each nursing unit. The decision maker wishes to select that mix which will minimize the loss to the hospital (the collection rate is less than cost on all categories of patients), within the constraints of nurse staffing and student teaching requirements. The loss to the hospital per patient day has been estimated as \$20 for intensive care, \$15 for intermediate care, and \$10 for minimal care. Because of considerations of general operating economy and overall teaching requirements it has been decided that there will be at least 30 beds per nursing unit. Also, for teaching purposes, there must be at least 5 intensive care, 10 intermediate care, and 7 minimal care beds. Because of nurse staffing limitations there must be no more than 80 hours of direct nursing care required per day on the nursing unit, where intensive care patients require 4 hours per day, intermediate 2, and minimal 1. This problem may be stated mathematically as follows:

$$\text{Minimize } 20X_1 + 15X_2 + 10X_3$$

$$\text{ST } X_1 + X_2 + X_3 \geq 30 \quad - \text{ for general operating economy and overall teaching}$$

$$4X_1 + 2X_2 + X_3 \leq 80 \quad - \text{ nursing constraint}$$

$$\left. \begin{array}{l} X_1 \geq 5 \\ X_2 \geq 10 \\ X_3 \geq 7 \end{array} \right\} \quad \text{teaching constraints}$$

Where X_1 = the number of intensive care beds

X_2 = the number of intermediate care beds

X_3 = the number of minimal care beds.

(The foregoing problem formulation assumes 100 per cent occupancy in all bed categories. This assumption could easily be relaxed without changing the nature of the problem.)

The simplex method will be used in the solution of this problem.⁶

The following tableaus represent the iterations of the method:

| C_i | X_i | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 | X_{10} | X_{11} | X_{12} | X_0 | b_i/a_{i3} |
|------------|----------|----------|----------|----------|-----------|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-------|-----------------|
| $-\infty$ | X_9 | 1 | 1 | 1 | -1 | | | | | 1 | | | | 30 | 30 |
| 0 | X_5 | 4 | 2 | 1 | | 1 | | | | | | | | 80 | 80 |
| $-\infty$ | X_{10} | 1 | | | | | -1 | | | | 1 | | | 5 | ∞ |
| $-\infty$ | X_{11} | | 1 | | | | | -1 | | | | 1 | | 10 | ∞ |
| $-\infty$ | X_{12} | | | 1 | | | | | -1 | | | | 1 | 7 | $7 \rightarrow$ |
| C_i | | -20 | -15 | -10 | 0 | 0 | 0 | 0 | 0 | $-\infty$ | $-\infty$ | $-\infty$ | $-\infty$ | | |
| Sol. | | 0 | 0 | 0 | 0 | 80 | 0 | 0 | 0 | 30 | 5 | 10 | 7 | | |
| Δ_j | | ∞ | ∞ | ∞ | $-\infty$ | 0 | $-\infty$ | $-\infty$ | $-\infty$ | 0 | 0 | 0 | 0 | | |

⁶For a detailed description of this method, see, for example, Sasieni, *op. cit.*, pp. 227-236.

| C_i | X_i | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 | X_{10} | X_{11} | X_0 | b_i/a_{i2} |
|-----------|------------|----------|----------|-------|-----------|-------|-----------|-----------|----------|-----------|-----------|-----------|-------|------------------|
| $-\infty$ | X_9 | 1 | 1 | 0 | -1 | | | | 1 | 1 | | | 23 | 23 |
| 0 | X_5 | 4 | 2 | 0 | | 1 | | | 1 | | | | 73 | 36.5 |
| $-\infty$ | X_{10} | 1 | | | | | -1 | | | | 1 | | 5 | ∞ |
| $-\infty$ | X_{11} | | 1 | | | | | -1 | | | | 1 | 10 | $10 \rightarrow$ |
| -10 | X_3 | | | 1 | | | | | -1 | | | | 7 | ∞ |
| | C_i | -20 | -15 | -10 | 0 | 0 | 0 | 0 | 0 | $-\infty$ | $-\infty$ | $-\infty$ | | |
| | Sol. | 0 | 0 | 7 | 0 | 73 | 0 | 0 | 0 | 23 | 5 | 10 | | |
| | Δ_j | ∞ | ∞ | 0 | $-\infty$ | 0 | $-\infty$ | $-\infty$ | ∞ | 0 | 0 | 0 | | |

| C_i | X_i | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 | X_{10} | X_0 | b_i/a_{i1} |
|-----------|------------|------------------------|-------|-------|-----------|-------|-----------|----------|----------|-----------|-----------|-------|-----------------|
| $-\infty$ | X_9 | 1 | 0 | | -1 | | | 1 | 1 | 1 | | 13 | 13 |
| 0 | X_5 | 4 | 0 | | | 1 | | 2 | 1 | | | 53 | 13 1/4 |
| $-\infty$ | X_{10} | 1 | | | | | -1 | | | | 1 | 5 | 5 \rightarrow |
| -15 | X_2 | | 1 | | | | | -1 | | | | 10 | ∞ |
| -10 | X_3 | | | 1 | | | | | -1 | | | 7 | ∞ |
| | C_i | -20 | -15 | -10 | 0 | 0 | 0 | 0 | 0 | $-\infty$ | $-\infty$ | | |
| | Sol. | 0 | 10 | 7 | 0 | 53 | 0 | 0 | 0 | 13 | 5 | | |
| | Δ_j | ∞ \uparrow | 0 | 0 | $-\infty$ | 0 | $-\infty$ | ∞ | ∞ | 0 | 0 | | |

| C_i | X_i | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 | X_0 | b_i/a_{i8} |
|------------|-------|-------|-------|-------|-----------|-------|----------|----------|----------|-----------|-------|-----------------|
| $-\infty$ | X_9 | | | | -1 | | 1 | 1 | 1 | 1 | 8 | $8 \rightarrow$ |
| 0 | X_5 | | | | | 1 | 4 | 2 | 1 | | 33 | 33 |
| -20 | X_1 | 1 | | | | | -1 | | | | 5 | ∞ |
| -15 | X_2 | | 1 | | | | | -1 | | | 10 | ∞ |
| -10 | X_3 | | | 1 | | | | | -1 | | 7 | -7 |
| C_i | | -20 | -15 | -10 | 0 | 0 | 0 | 0 | 0 | $-\infty$ | | |
| Sol. | | 5 | 10 | 7 | 0 | 33 | 0 | 0 | 0 | 8 | | |
| Δ_j | | 0 | 0 | 0 | $-\infty$ | 0 | ∞ | ∞ | ∞ | 0 | | |

| C_i | X_i | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_0 | b_i/a_i |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
| 0 | X_8 | | | | -1 | | 1 | 1 | 1 | 8 | |
| 0 | X_5 | | | | 1 | 1 | 3 | 1 | | 25 | |
| -20 | X_1 | 1 | | | | | -1 | | | 5 | |
| -15 | X_2 | | 1 | | | | | -1 | | 10 | |
| -10 | X_3 | | | 1 | -1 | | 1 | 1 | | 15 | |
| C_i | | -20 | -15 | -10 | 0 | 0 | 0 | 0 | 0 | | |
| Sol. | | 5 | 10 | 15 | 0 | 25 | 0 | 0 | 8 | | |
| Δ_j | | 0 | 0 | 0 | -10 | 0 | -10 | -5 | 0 | | |

From the above we see that the optimal solution is 5 intensive care beds, 10 intermediate, and 15 minimal. This results in a daily loss of $5(\$20) + 10(\$15) + 15(\$10) = \400 .

Dynamic Programming

Let us assume that an institution is attempting to develop a phased master plan of clinical facilities construction over the next ten years in order to meet the needs of an expanding student enrollment. The construction and financing requirements are such that construction projects may begin every other year, and the time required for construction is two years. The following costs have been estimated:

C_c = cost for having excess capacity = \$4,000/bed/period (2 yrs.)

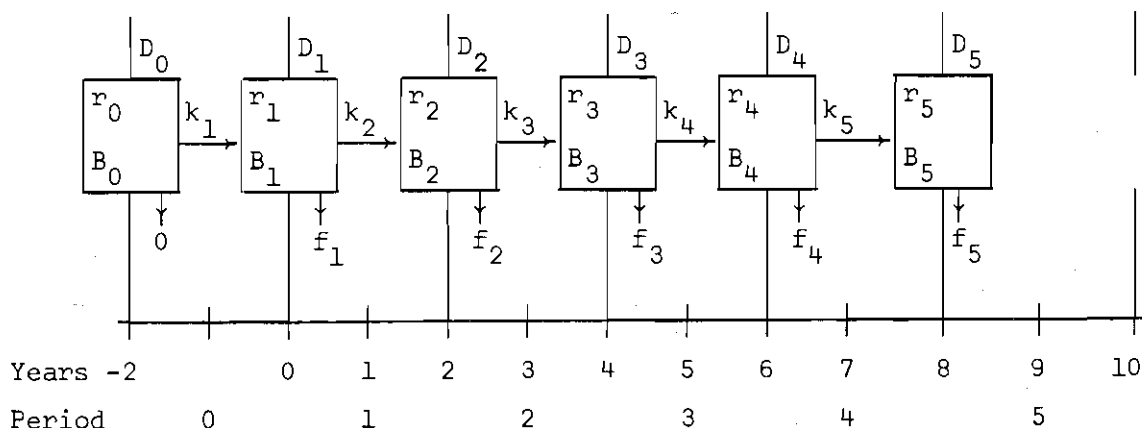
C_u = cost for having insufficient capacity = \$6,000/bed/period

C_o = cost/project for undertaking to add capacity = \$150,000.

It is assumed that the required facilities will eventually be constructed; therefore constructions costs are not considered in this formulation. The need for additional clinical facilities (beds) has been projected as follows:

| <u>Years</u> | <u>Period(i)</u> | <u>D_i</u> | <u>ΣD_i</u> |
|--------------|------------------|-------------------------|--------------------------------|
| 1 & 2 | 1 | 20 | 20 |
| 3 & 4 | 2 | 40 | 60 |
| 5 & 6 | 3 | 80 | 140 |
| 7 & 8 | 4 | 20 | 160 |
| 9 & 10 | 5 | 10 | 170 |

This problem can be portrayed as a sequential decision making problem as follows:



where, B_i = capacity to be installed during period i

$$k_i = \text{available capacity during period } i = \sum_{j=0}^{i-1} B_j$$

D_i = increase in demand for period i

$$r_i = \begin{cases} 0 & \text{when no additional capacity is installed during period } i \\ 1 & \text{when additional capacity is installed during period } i \end{cases}$$

$$\begin{aligned} f_n = f_n(k_n, r_{n-1}) &= r_{n-1}C_o + \left\{ \sum_{i=0}^n D_i - K_n \right\} C_u, \text{ for } \sum_{i=0}^n D_i - K_n \geq 0 \\ &= r_{n-1}C_o + \left\{ k_n - \sum_{i=0}^n D_i \right\} C_c, \text{ for } \sum_{i=0}^n D_i - K_n < 0 \end{aligned}$$

$$K_i \in \{0, 20, 60, 140, 160, 170\}, \text{ and } k_{n+1} \in \{k_n, \dots, 170\}$$

Let,

$$g_n(k_n) = f_n(k_n, r_{n-1}) + \min_{k_i} \left\{ \sum_{i=n+1}^5 f_i(k_i, r_{i-1}) \right\} = \text{minimum cost for specified policy}$$

$$g_n^*(k_n) = \min_{k_n} \left\{ f_n(k_n, r_{n-1}) + \min_{k_i} \left\{ \sum_{i=n+1}^5 f_i(k_i, r_{i-1}) \right\} \right\} = \text{optimal cost}$$

This problem can now be solved by an algorithm based upon Bellman's *optimality principle*:⁷

An optimal policy has the property that, whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with respect to the state resulting from the first decision.

First, tables are constructed showing the possible inputs, outputs, and returns at each stage of the decision process.

Stage 5

In stage 5 there are no outputs nor decisions, therefore only an input-return-matrix is required.

Table of f_5

| $K_5 \backslash r_4$ | 0 | 1 |
|----------------------|------|------|
| 0 | 1020 | |
| 20 | 900 | 1050 |
| 60 | 660 | 810 |
| 140 | 180 | 330 |
| 160 | 60 | 210 |
| 170 | 0 | 150 |

$f_5 = (0,1)150 + 6(170-k_5)$
 $f_5 = (0,1)150 + 4(k_5-170)$

⁷As stated in Sasieni, *op. cit.*, p. 272.

Stage 4Table of k_5

| $K_4 \backslash r_4$ | 0 | 1 |
|----------------------|-----|-----|
| | 0 | 170 |
| 0 | 0 | 170 |
| 20 | 20 | 170 |
| 60 | 60 | 170 |
| 140 | 140 | 170 |
| 160 | 160 | 170 |
| 170 | 170 | |

Table of f_4

| $K_4 \backslash r_3$ | 0 | 1 |
|----------------------|-----|------|
| | 0 | 1 |
| 0 | 960 | 1110 |
| 20 | 840 | 990 |
| 60 | 600 | 750 |
| 140 | 120 | 270 |
| 160 | 0 | 150 |
| 170 | 40 | 190 |

$f_4 = (0,1)150 + 6(160-k_4)$
 $f_4 = (0,1)150 + 4(k_4-160)$

Stage 3Table of k_4

| $k_3 \backslash r_3$ | 0 | 1 | |
|----------------------|-----|-----|-----|
| | 0 | 160 | 170 |
| 0 | 0 | 160 | 170 |
| 20 | 20 | 160 | 170 |
| 60 | 60 | 160 | 170 |
| 140 | 140 | 160 | 170 |
| 160 | 160 | | 170 |
| 170 | 170 | | |

Table of f_3

| $K_3 \backslash r_2$ | 0 | 1 |
|----------------------|-----|-----|
| | 0 | 1 |
| 0 | 840 | 990 |
| 20 | 720 | 870 |
| 60 | 480 | 630 |
| 140 | 0 | 150 |
| 160 | 80 | 230 |
| 170 | 120 | 270 |

$f_3 = (0,1)150 + (140-k_3)6$
 $f_3 = (0,1)150 + (k_3-140)4$

Stage 2Table of k_3

| $k_2 \backslash r_2$ | | 1 | | |
|----------------------|-----|-----|-----|-----|
| | 0 | | | |
| | 0 | 140 | 160 | 170 |
| 0 | 0 | 140 | 160 | 170 |
| 20 | 20 | 140 | 160 | 170 |
| 60 | 60 | 140 | 160 | 170 |
| 140 | 140 | | 160 | 170 |
| 160 | 160 | | | 170 |
| 170 | 170 | | | |

Table of f_2

| $k_2 \backslash r_1$ | | 1 | |
|----------------------|-----|-----|--------------------------------|
| | 0 | | |
| | 0 | 360 | 510 |
| 20 | 240 | 390 | } $f_2 = (0,1)150 + 6(60-k_2)$ |
| 60 | 0 | 150 | |
| 140 | 320 | 470 | } $f_2 = (0,1)150 + 4(k_2-60)$ |
| 160 | 400 | 550 | |
| 170 | 440 | 590 | |

Stage 1Table of k_2

| $k_1 \backslash r_1$ | | 1 | | | |
|----------------------|-----|----|-----|-----|-----|
| | 0 | 60 | 140 | 160 | 170 |
| 0 | 0 | 60 | 140 | 160 | 170 |
| 20 | 20 | 60 | 140 | 160 | 170 |
| 60 | 60 | | 140 | 160 | 170 |
| 140 | 140 | | | 160 | 170 |
| 160 | 160 | | | | 170 |
| 170 | 170 | | | | |

Table of f_1

| $k_1 \backslash r_0$ | | 1 | |
|----------------------|-----|-----|--------------------------------|
| | 0 | | |
| | 0 | 120 | 270 |
| 20 | 0 | 150 | } $f_1 = (0,1)150 + 6(20-k_1)$ |
| 60 | 160 | 310 | |
| 140 | 480 | 630 | } $f_1 = (0,1)150 + 4(k_1-20)$ |
| 160 | 560 | 710 | |
| 170 | 600 | 750 | |

The above tables can now be used to find the optimal solution to this problem. We start first with stage 5 and work back through successive stages in turn, determining the optimal decision for each possible input. The optimal decision at any stage involves the selection of that path (collection of decisions) spanning all following stages (in this example, higher number stages) which produces the lowest cost for the input being considered at that stage. By working backwards through time we are able to eliminate all paths but one for each possible input at a given stage, thereby eliminating the need to compute the total cost of each possible path of the decision process. This efficiency and relative ease in computation is the primary advantage of the application of dynamic programming in sequential decision making.

The evaluation of each stage and the selection of the optimal alternative is shown below:

Let,

$$f'_n = f_n - 150r_{n-1}$$

$$g'_n(k_n) = f'_n + g_{n+1}^*(k_{n+1})$$

$$g_n(k_n) = g'_n(k_n) + r_{n-1}(150)$$

The evaluation for Stage 5 is the f_5 table shown above.

Stage 4

| k_4 | f'_4 | r_4 | k_5 | f_5 | $f'_4 + f_5$ | |
|-------|--------|-------|-------|-------|--------------|------------------------|
| 0 | 960 | 0 | 0 | 1020 | 1980 | $\leftarrow g'_4(0)$ |
| | | 1 | 170 | 150 | 1110 | |
| 20 | 840 | 0 | 20 | 900 | 1740 | $\leftarrow g'_4(20)$ |
| | | 1 | 170 | 150 | 990 | |
| 60 | 600 | 0 | 60 | 660 | 1260 | $\leftarrow g'_4(60)$ |
| | | 1 | 170 | 150 | 750 | |
| 140 | 120 | 0 | 140 | 180 | 300 | $\leftarrow g'_4(140)$ |
| | | 1 | 170 | 150 | 270 | |
| 160 | 0 | 0 | 160 | 60 | 60 | $\leftarrow g'_4(160)$ |
| | | 1 | 170 | 150 | 150 | |
| 170 | 40 | 0 | 170 | 0 | 40 | $\leftarrow g'_4(170)$ |
| | | | | | | |

Stage 3

| K_3 | f'_3 | r_3 | k_4 | g_4 | $f'_3 + g_4$ | |
|-------|--------|-------|-------|-------|--------------|------------------------|
| 0 | 840 | 0 | 0 | 1110 | 1950 | $\leftarrow g'_3(0)$ |
| | | | 160 | 210 | 1050 | |
| | | 1 | 170 | 190 | 1030 | $\leftarrow g'_3(20)$ |
| 20 | 720 | 0 | 20 | 990 | 1710 | |
| | | | 160 | 210 | 930 | $\leftarrow g'_3(60)$ |
| | | 1 | 170 | 190 | 890 | |
| 60 | 480 | 0 | 60 | 750 | 1230 | $\leftarrow g'_3(140)$ |
| | | | 160 | 210 | 690 | |
| | | 1 | 170 | 190 | 670 | $\leftarrow g'_3(160)$ |
| 140 | 0 | 0 | 140 | 270 | 270 | |
| | | | 160 | 210 | 210 | $\leftarrow g'_3(170)$ |
| | | 1 | 170 | 190 | 190 | |
| 160 | 80 | 0 | 160 | 60 | 140 | $\leftarrow g'_3(170)$ |
| | | | | | | |
| | | 1 | 170 | 190 | 270 | $\leftarrow g'_3(170)$ |
| 170 | 120 | 0 | 170 | 40 | 160 | |
| | | | | | | $\leftarrow g'_3(170)$ |
| | | 1 | | | | |

Stage 2

| K_2 | f'_2 | r_2 | k_3 | g_3 | $f'_2 + g_3$ | |
|-------|--------|-------|-------|-------|--------------|------------------------|
| 0 | 360 | 0 | 0 | 1030 | 1390 | |
| | | 1 | 140 | 340 | 700 | $\leftarrow g'_2(0)$ |
| | | | 160 | 290 | 650 | |
| | | | 170 | 310 | 670 | |
| 20 | 240 | 0 | 20 | 890 | 1130 | |
| | | 1 | 140 | 340 | 580 | $\leftarrow g'_2(20)$ |
| | | | 160 | 290 | 530 | |
| | | | 170 | 310 | 550 | |
| 60 | 0 | 0 | 60 | 670 | 670 | |
| | | 1 | 140 | 340 | 340 | $\leftarrow g'_2(60)$ |
| | | | 160 | 290 | 290 | |
| | | | 170 | 310 | 310 | |
| 140 | 320 | 0 | 140 | 190 | 510 | $\leftarrow g'_2(140)$ |
| | | 1 | | | | |
| | | | 160 | 290 | 610 | |
| | | | 170 | 310 | 630 | |
| 160 | 400 | 0 | 160 | 140 | 540 | $\leftarrow g'_2(160)$ |
| | | 1 | | | | |
| | | | | | | |
| | | | 170 | 310 | 710 | |
| 170 | 440 | 0 | 170 | 160 | 600 | $\leftarrow g'_2(170)$ |
| | | 1 | | | | |
| | | | | | | |
| | | | | | | |

Stage 1

| K_1 | f'_1 | r_1 | k_2 | g_2 | $f'_1 + g_2$ | |
|-------|--------|-------|-------|-------|--------------|------------------------|
| 0 | 120 | 0 | 0 | 650 | 770 | $\leftarrow g'_1(0)$ |
| | | 1 | 60 | 440 | 560 | |
| | | | 140 | 660 | 780 | |
| | | | 160 | 690 | 810 | |
| | | | 170 | 750 | 870 | |
| 20 | 0 | 0 | 20 | 530 | 530 | $\leftarrow g'_1(20)$ |
| | | 1 | 60 | 440 | 440 | |
| | | | 140 | 660 | 660 | |
| | | | 160 | 690 | 690 | |
| | | | 170 | 750 | 750 | |
| 60 | 160 | 0 | 60 | 290 | 450 | $\leftarrow g'_1(60)$ |
| | | 1 | | | | |
| | | | 140 | 660 | 820 | |
| | | | 160 | 690 | 850 | |
| | | | 170 | 750 | 910 | |
| 140 | 480 | 0 | 140 | 510 | 990 | $\leftarrow g'_1(140)$ |
| | | 1 | | | | |
| | | | 160 | 690 | 1170 | |
| | | | 170 | 750 | 1230 | |
| | | | | | | |
| 160 | 560 | 0 | 160 | 540 | 1100 | $\leftarrow g'_1(160)$ |
| | | 1 | | | | |
| | | | | | | |
| | | | | | | |
| | | | 170 | 750 | 1310 | |
| 170 | 600 | 0 | 170 | 600 | 1200 | $\leftarrow g'_1(170)$ |

Stage 0

| r_0 | k_1 | g_1 | |
|-------|-------|--------------|--------------|
| 0 | 0 | 560 | \leftarrow |
| 1 | 20 | 440 + 150 = | 590 |
| | 60 | 450 + 150 = | 600 |
| | 140 | 990 + 150 + | 1140 |
| | 160 | 1100 + 150 = | 1250 |
| | 170 | 1200 + 150 = | 1350 |

The optimal path is summarized below:

| Years | Period | B_{i-1} | ΣB_{i-1} | ΣDi | Cu&c | Co | ΣC |
|------------|--------|-----------|------------------|-------------|------|-----|-------------------|
| | 0 | 0 | 0 | 0 | 0 | | 0 |
| 1-2 | 1 | 0 | 0 | 20 | 120 | | 120 |
| 3-4 | 2 | 60 | 60 | 60 | 0 | 150 | 150 |
| 5-6 | 3 | 100 | 160 | 140 | 80 | 150 | 230 |
| 7-8 | 4 | 0 | 160 | 160 | 0 | | 0 |
| 9-10 | 5 | 0 | 160 | 170 | 60 | | <u>60</u> |
| TOTAL COST | | | | | | | <u><u>560</u></u> |

Therefore, the optimal construction schedule is to begin construction of 60 beds at the beginning of year 1 for completion by the first of year 3, at which time an additional 100 beds would be begun for completion at the first of year 5. Beds needed over and above those available during years 1-2 and 9-10 can be more economically "rented" than constructed.

Inventory Problem

Patients needing a particular type of surgery are expected to be admitted to or identified within a particular hospital at a rate of 1 per day. The cost per day of holding a patient in the hospital awaiting surgery is \$50. The cost of preparatory tests and procedures for each patient varies inversely with the time allowed for their performance according to the following equation:

$$\text{Cost} = 50 + \frac{50}{\text{time (days)}}$$

These surgery cases are to be handled in groups, and the "set-up" cost (i.e., assembling the team, preparing the room and equipment, etc.) for each group is approximately \$1,000. The cost of the facilities on an amortized basis is estimated at \$9.00 per operating room per day. An average of 3 operations per room per day can be performed. How frequently should groups be scheduled (i.e., how many operating rooms should be constructed?) and what should be the minimum time allowed for preparatory tests and procedures prior to an operation? (As an approximation we will assume that all variables are continuous.)

Let,

C_1 = cost per day of holding a patient in hospital awaiting surgery.

$C_2(T_s)$ = cost of preparatory tests and procedures per patient.

C_3 = "set-up" costs per group.

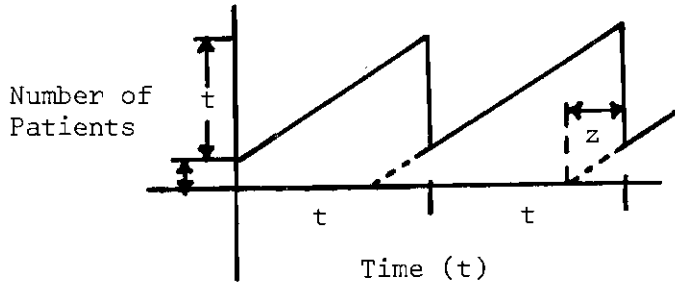
C_4 = amortized facility cost per room per day.

N = average number of operations per day per room.

Z = minimum time allowed for preparatory tests and procedures.

T = time between groups of operations.

The following sketch indicates the variation over time of the number of patients in the hospital awaiting surgery:



The total cost for holding patients during time t is

$$C_1 \left[\frac{1}{2}(t)(t) + (z)(t) \right]$$

The total cost of preparatory tests and procedures for the group of patients undergoing surgery every period of time t is

$$\begin{aligned} \int_z^{t+z} C_2(T_s) dT_s &= \int_z^{t+z} \left(50 + \frac{50}{T_s} \right) dT_s = 50(T_s + \ln(T_s)) \Big|_z^{t+z} \\ &= 50t + 50(\ln(t+z) - \ln(z)) \end{aligned}$$

Total costs for one group of patients = total holding cost + total cost of preparatory tests and procedures + set-up costs + facility costs =
 $C_1 \left(\frac{1}{2}t^2 + zt \right) + 50t + 50(\ln(t+z) - \ln(z)) + C_3 + \frac{C_4 t^2}{N}$.

Average cost per day = $C_1 \left(\frac{1}{2}t + z \right) + 50 + \frac{50}{t} (\ln(t+z) - \ln(z)) + C_3/t + \frac{C_4 t}{N} = C$.

$$\frac{\partial C}{\partial t} = \frac{C_1}{2} - \frac{50}{t^2} (\ln(t+z) - \ln(z)) + \frac{50}{t} \frac{1}{(t+z)} - \frac{C_3}{t^2} + \frac{C_4}{N}$$

$$\frac{\partial C}{\partial z} = C_1 + \frac{50}{t} \left(\frac{1}{t+z} - \frac{1}{z} \right)$$

Substitute the values of the costs, and set partial derivatives equal to zero to obtain minimum point (sufficient conditions will not be tested):

$$\frac{\partial C}{\partial z} = 50 + \frac{50}{t} \left(\frac{1}{t+z} - \frac{1}{z} \right) = 0; \quad t = \frac{1}{z} - \frac{1}{t+z} = \frac{t+z-z}{z(t+z)} = \frac{t}{z(t+z)}$$

$$z(t+z) = 1; \quad t = \frac{1}{z} - z = \frac{1-z^2}{z}$$

$$\frac{\partial C}{\partial t} = 25 - \frac{50}{t^2} (\ln(t+z) - \ln(z)) + \frac{50}{t} \left(\frac{1}{t+z} \right) - \frac{1,000}{t^2} + 3 \stackrel{!}{=} 0$$

Substitute $t = \frac{1-z^2}{z}$ and obtain

$$28 - 50 \left(\frac{z}{1-z^2} \right)^2 \left(\ln \left(\frac{1}{z} \right) - \ln(z) \right) + 50 \left(\frac{z}{1-z^2} \right) z - 1000 \left(\frac{z}{1-z^2} \right)^2 \stackrel{!}{=} 0$$

The following solution to this equation was found by trial and error:

$$z = .154$$

$$t = 6.346$$

For this value of t ,

$$C = 50 \left[\frac{1}{2} [6.346] + .154 \right] + 50 + \frac{50}{6.346} (\ln(6.346 + .154) - \ln(.154))$$

$$+ \frac{1000}{6.346} + \frac{9(6.346)}{3} = 422.14.$$

Since it will probably be necessary to schedule surgery times in multiples of whole days, the average cost per day for $t = 6$ and 7 days were computed, as follows:

For $t = 6$, $Z = .16$, and

$$C = 50 \left[\frac{1}{2} (6) + .16 \right] + 50 + \frac{50}{6} [\ln(6.16) - \ln(.16)] + \frac{1000}{6} + \frac{9(6)}{3}$$

$$= 423.12.$$

For $t = 7$, $Z = .14$, and

$$C = 50 \left[\frac{1}{2} (7) + .14 \right] + 50 + \frac{50}{7} [\ln(7.14) - \ln(.14)] + \frac{1000}{7} + \frac{9(7)}{3}$$

$$= 423.94.$$

Since there is very little difference between the costs for 6 and 7 days it is likely that 7 days between surgery groups would be selected so that this particular type of surgery occurs on the same

day of every week. The minimum time allowed for preparation for surgery should be .14 day.

Replacement Model

In any large building program involving the addition of facilities to an existing plant, there is the question of whether certain existing supporting service facilities should be replaced, renovated, or used as they presently exist. An example along these lines would be that of deciding whether or not to build a new laundry at the time an addition to the existing hospital is constructed. To illustrate the use of economic replacement models in this type of situation, let us assume the existence of the following conditions and facts regarding this problem:

- The present laundry could handle the additional workload by going to a multi-shift operation. Shift-differential pay would be required. The evening shift pays an extra \$.30 per hour, and the night shift pays an extra \$.50 per hour.
- Construction cost for a given amount of new laundry facilities would be less if added along with the hospital addition than if built under a separate project, because of project "start-up" costs. It is estimated that the cost would be approximately 10 per cent more if handled separately.
- The planning horizon for the laundry is taken to be the same as that for the hospital addition; 15 years.
- The average total cost of labor per hour in the laundry is expected to approximate \$2.00 in the first year (1970) and increase \$.10 per hour each year thereafter through 1985.
- The salvage value, productivity, and maintenance costs of laundry facilities are estimated to be approximately as follows:

| | | | | | | | | | | | | | | | |
|---|-----|-----|-----|-----|-----|----|----|------|----|----|----|------|----|------|----|
| Years of Use | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Value (% of original) | 80 | 75 | 70 | 65 | 60 | 60 | 55 | 55 | 50 | 50 | 40 | 30 | 20 | 10 | 10 |
| Productivity (% of original) | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 96.5 | 95 | 93 | 91 | 88.5 | 86 | 83.5 | 81 |
| *Maintenance Cost (% of original price) | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 7 | 7 | 8 | 9 | 11 | 13 | 15 |

--The addition to the hospital will increase the laundry workload to 200 per cent of the present day-shift (8 hours) capacity. The laundry is presently operating at 80 per cent capacity.

--The cost of renovation and new facilities for the increased load for a single shift is estimated as \$150,000. The costs for 2 and 3 shift operations are 1/2 and 1/3, respectively.

--The present operating expenses (labor and overhead) are \$208,000 per year.

--The "time value of money" for the institution is taken to be 6 per cent.

--The new types of laundry equipment now on the market are 20 per cent more productive than the present equipment. The present facilities are ten years old. Their estimated market value is \$60,000.

The planners need to know when, from an economic point of view, they should renovate and add new laundry facilities and whether multiple shifts should be planned. It will be assumed that no more than two facility replacements during the 15-year period will be considered.

The following estimates are required in order to make the economic calculations for each alternative:

* Values shown are for single-shift operation. Double- and triple-shifts would be two and three times these values, respectively.

$$\text{The present no. of equivalent workers} = \frac{\$208,000}{\$2(\text{hrs/yr})} = \frac{\$208,000}{\$2(2080)} = 50$$

$$\text{Present capacity} = \frac{50}{.8} = 63 \text{ equivalent workers} = 131,040 \text{ labor hrs.} \\ \text{or } 63(2080)$$

$$\text{Initial labor hrs. required in old facilities} = 2(131,040) = 262,080$$

$$\text{Initial labor hrs. required in new facilities} = \frac{262,080}{1.2} = 218,400$$

First we will consider the case in which there is no more than one replacement within the 15-year period. The economic model used to determine the optimal solution in this case is as follows:

Let,

I_o = the present value of the existing facilities.

C_{oj} = operating and maintenance costs for present facilities during the j th additional year of use.

S_{oj} = salvage value of present facilities at the end of the j th additional year of use.

I_1 = investment required for new facilities.

C_{1j} = operating and maintenance cost for new facilities during year j .

S_{1j} = salvage value of new facilities at the end of the j th year of use.

We need to find the value of n which minimizes

$$TC(n) = I_o + \sum_{j=1}^n \frac{C_{oj}}{(1+i)^j} - \frac{S_{on}}{(1+i)^n} + \frac{I_1}{(1+i)^n} + \sum_{j=1}^{15-n} \frac{C_{1j}}{(1+i)^{n+j}} - \frac{S_{1,15-n}}{(1+i)^{15}}$$

The first three terms of the above expression represent the cost of owning and operating the present facilities for the next n years. The calculation of this cost for $n=1, \dots, 5$ is shown in Table 1. Column 1 contains I_0 ; column 9 contains $\sum_{j=1}^n \frac{C_{oj}}{(1+i)^j}$; column 10 contains $S_{on}/(1+i)^n$; and column 11 contains the combination of these terms, or total cost for present equipment.

One Replacement, Single-Shift. The last three terms of the total cost expression above represent the cost of owning and operating the renovated and new facilities for $15-n$ years, where n = the number of years the old facilities continue to be used. The calculations of this cost to $n = 0, 1, \dots, 15$ are shown in Table 2.

Notation is changed slightly in Table 2; n_0 represents the number of years the old facilities continue to be used, and n_1 represents the number of years the new facilities are used within the 15-year period. The method of computation for Table 2, columns 1-11, is the same as that of Table 1. Therefore, column 11 contains the cost of owning and operating the renovated and new facilities for n_1 years discounted to its present worth at the time of installation. Column 13 contains this cost further discounted to the time of the decision under investigation, i.e., time zero.

The results of computations in Tables 1 and 2 are combined in Table 3 to show the total present worth of costs for the 15-year period under several different replacement time assumptions. Not all possible replacement times are shown since it was clear after a few calculations that the optimal solution is to replace the old facilities at time zero. The present worth of total cost in this case is \$6,007,784.

Table 1. Cost for Present Equipment

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|----------|----------------|------------------------------------|---------------------------------|------------------------|---------------------------------|---|-------|----------------|--------------|------------------|
| n | I | S _j | Labor Hrs/ Year _j | Cost/ Labor Hour | Labor Cost/ Year | Maintenance Cost Per Year | Total Labor & Maintenance Cost | PWF' | Σ PW of (7) | PW of (2) | (1)+(9)- (10) |
| 1 | (60,000) | 48,000 | (238,493) 262,080 | (131,040) 2.00/2.30/ 2.50 | 563,472 | (120,000) 9,600 | 573,072 | .9434 | 540,636 | 45,283 | 555,353 |
| 2 | | 36,000 | 269,483 | 2.10/2.40/ 2.60 | 608,928 | 10,800 | 619,728 | .8900 | 1,092,194 | 32,040 | 1,120,154 |
| 3 | | 24,000 | 277,317 | 2.20/2.50/ 2.70 | 657,028 | 13,200 | 670,288 | .8396 | 1,654,917 | 20,150 | 1,694,767 |
| 4 | | 12,000 | 285,620 | 2.30/2.60/ 2.80 | 708,008 | 15,600 | 723,608 | .7921 | 2,228,087 | 9,505 | 2,278,582 |
| 5 | | 12,000 | 294,435 | 2.40/2.70/ 2.90 | 762,134 | 18,000 | 780,134 | .7473 | 2,811,082 | 8,968 | 2,862,114 |

Table 2. Cost for Replacement Equipment (One Replacement, Single Shift)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|-------|---------|----------|-------------------------------|------------------------|---------------------------|-------------------------------|------------------------------------|-------|------------------------------|------------|------------------------------|------------------|------------------------------|
| n_1 | I_1 | S_{1j} | Labor Hours per Year | Cost/ Labor Hour | Labor Cost Per Year | Maint. Cost Per Year | Total Labor & Maint. Cost | PWF' | EPW of 7 | PW of 2 | $1+9-10$ | PWF' $15-n_1$ | 11×12 |
| 1 | 150,000 | 120,000 | 218,400 | $2+.1n_0$ | $436,800+$ $21,840n_0$ | 7,500 | $444,300+$ $21,840n_0$ | .9434 | $419,153+$ $20,604n_0$ | 113,208 | $445,945+$ $20,604n_0$ | .4423 | $201,664+$ $9,113n_0$ |
| 2 | 150,000 | 112,500 | 218,400 | $2.1+.1n_0$ | $458,640+$ $21,840n_0$ | 7,500 | $466,140+$ $21,840n_0$ | .8900 | $834,017+$ $40,041n_0$ | 100,125 | $883,891+$ $40,041n_0$ | .4688 | $414,369+$ $18,759n_0$ |
| 3 | 150,000 | 105,000 | 218,400 | $2.2+.1n_0$ | $480,480+$ $21,840n_0$ | 7,500 | $487,980+$ $21,840n_0$ | .8396 | $1,243,725+$ $58,378n_0$ | 88,158 | $1,305,567+$ $58,378n_0$ | .4970 | $648,867+$ $29,014n_0$ |
| 4 | 150,000 | 97,500 | 218,400 | $2.3+.1n_0$ | $502,320+$ $21,840n_0$ | 7,500 | $509,820+$ $21,840n_0$ | .7921 | $1,647,554+$ $75,678n_0$ | 77,230 | $1,720,324+$ $75,678n_0$ | .5268 | $906,267+$ $39,867n_0$ |
| 5 | 150,000 | 90,000 | 218,400 | $2.4+.1n_0$ | $524,160+$ $21,840n_0$ | 7,500 | $531,660+$ $21,840n_0$ | .7473 | $2,044,863+$ $91,999n_0$ | 67,257 | $2,127,606+$ $91,999n_0$ | .5584 | $1,188,055+$ $51,372n_0$ |
| 6 | 150,000 | 90,000 | 220,606 | $2.5+.1n_0$ | $551,515+$ $22,061n_0$ | 9,000 | $560,515+$ $22,061n_0$ | .7050 | $2,440,026+$ $107,552n_0$ | 63,450 | $2,526,576+$ $107,552n_0$ | .5915 | $1,494,470+$ $63,617n_0$ |
| 7 | 150,000 | 82,500 | 222,857 | $2.6+.1n_0$ | $579,428$ $22,286n_0$ | 9,000 | $588,428+$ $22,286n_0$ | .6651 | $2,831,390+$ $122,374n_0$ | 54,871 | $2,926,519+$ $122,374n_0$ | .6274 | $1,836,098+$ $76,777n_0$ |
| 8 | 150,000 | 82,500 | 226,321 | $2.7+.1n_0$ | $611,067+$ $22,631n_0$ | 9,000 | $620,067+$ $22,632n_0$ | .6274 | $3,220,420+$ $136,574n_0$ | 51,761 | $3,318,659+$ $136,574n_0$ | .6651 | $2,207,240+$ $90,835n_0$ |
| 9 | 150,000 | 75,000 | 229,894 | $2.8+.1n_0$ | $643,703+$ $22,989n_0$ | 10,500 | $654,203+$ $22,989n_0$ | .5915 | $3,607,381+$ $150,172n_0$ | 44,363 | $3,713,018+$ $150,172n_0$ | .7050 | $2,617,678+$ $105,871n_0$ |
| 10 | 150,000 | 75,000 | 234,838 | $2.9+.1n_0$ | $681,030+$ $23,484n_0$ | 10,500 | $691,530+$ $23,484n_0$ | .5584 | $3,993,531+$ $163,285n_0$ | 41,880 | $4,101,651+$ $163,285n_0$ | .7473 | $3,065,164+$ $122,023n_0$ |
| 11 | 150,000 | 60,000 | 240,000 | $3.0+.1n_0$ | $720,000+$ $24,000n_0$ | 12,000 | $732,000+$ $24,000n_0$ | .5268 | $4,379,149+$ $175,928n_0$ | 31,608 | $4,497,541+$ $175,928n_0$ | .7921 | $3,562,502+$ $139,353n_0$ |
| 12 | 150,000 | 45,000 | 246,779 | $3.1+.1n_0$ | $765,015+$ $24,678n_0$ | 13,500 | $778,515+$ $24,678n_0$ | .4970 | $4,766,071+$ $188,193n_0$ | 22,365 | $4,893,706+$ $188,193n_0$ | .8396 | $4,108,756+$ $158,007n_0$ |
| 13 | 150,000 | 30,000 | 253,953 | $3.2+.1n_0$ | $812,650+$ $25,395n_0$ | 16,500 | $829,150+$ $25,395n_0$ | .4688 | $5,154,776+$ $200,098n_0$ | 14,064 | $5,290,712+$ $200,098n_0$ | .8900 | $4,708,734+$ $178,087n_0$ |
| 14 | 150,000 | 15,000 | 261,556 | $3.3+.1n_0$ | $863,135+$ $26,156n_0$ | 19,500 | $882,635+$ $26,156n_0$ | .4423 | $5,545,166+$ $211,667n_0$ | 6,635 | $5,688,531+$ $211,667n_0$ | .9434 | $5,366,560+$ $199,687n_0$ |
| 15 | 136,364 | 13,636 | 269,629 | $3.4+.1n_0$ | $916,739+$ $26,963n_0$ | 22,500 | $939,239+$ $26,963n_0$ | .4173 | $5,937,110+$ $222,919n_0$ | 5,690 | $6,067,784+$ $222,919n_0$ | 1.000 | $6,067,784+$ $222,919n_0$ |

Table 3. Present Worth of Total Cost
(One Replacement, One Shift)

| n_0 | n_1 | PW Present Equipment | PW Replacement Equipment | Total PW | |
|-------|-------|----------------------------|--------------------------------|-----------|----------------------|
| 0 | 15 | (60,000) | 6,067,784 | 6,007,784 | ←Optimal Strategy |
| 1 | 14 | 555,353 | 5,566,247 | 6,121,600 | |
| 2 | 13 | 1,120,154 | 5,064,908 | 6,185,062 | |
| 3 | 12 | 1,694,767 | 4,582,777 | 6,277,544 | |
| 4 | 11 | 2,278,582 | 4,119,914 | 6,398,496 | |
| 5 | 10 | 2,862,114 | 3,675,279 | 6,537,393 | |
| . | .. | | | | |
| . | .. | | | | |

Since the above computations were for a single-shift operation of the replacement facilities, it is now necessary to consider the possibility of two- and three-shift operations.

One Replacement, Two Shifts. The following estimates are required in order to evaluate this alternative:

$$\text{Cost of renovation and new facilities} = \frac{1}{2}(\$136,364) = \$68,182.$$

$$\text{Salvage value after 15 years} = .1(68,182) = \$6,818.$$

$$\text{One-shift capacity} = \frac{1}{2}(269,629) = 134,815 \text{ man.}$$

$$\text{Cost/labor-hour for first shift} = 2 + .1(n-1).$$

$$\text{Cost/labor-hour for second shift} = 2.3 + .1(n-1).$$

Maintenance cost/year = the same as that shown in the single-shift table.

In order to avoid repeating the computations of Table 2 for this particular alternative the following method is used.

Let,

H = one-shift capacity expressed in manhours.

H_i = the number of manhours in the second shift during year i .

P_i = cost/labor-hour for first shift during year i .

F_i = single payment present worth factor for i years.

M_i = maintenance cost during year i .

The present worth of total labor and maintenance costs for 15 years may be expressed as follows:

$$\begin{aligned} \text{PW(labor \& maint. costs)} &= \sum_{i=1}^{15} [H(P_i) + H_i(P_i + .3) + M_i]F_i = \\ &= \sum_{i=1}^{15} [P_i(H+H_i) + .3H_i + M_i]F_i = \\ &= \sum_{i=1}^{15} [P_i(H+H_i) + M_i]F_i + \sum_{i=1}^{15} .3H_iF_i \end{aligned}$$

The first term in the right-hand side of this equation may be obtained from column 9 of Table 2.

The second term may be modified as follows:

$$\sum_{i=1}^{15} .3H_iF_i = .3 \sum_{i=1}^{15} [(H+H_i)F_i - HF_i] = .3 \left[\sum_{i=1}^{15} (H+H_i)F_i - H \sum_{i=1}^{15} F_i \right]$$

The quantity $\sum_{i=1}^{15} (H+H_i)F_i$ can be shown to be ten times the coefficient of

the n_0 term in column 9 of Table 2. The quantity $\sum_{i=1}^{15} F_i$ can be determined by the addition of column 8 of Table 2.

The present worth equation can now be written as follows:

$$\begin{aligned}
 PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) &= \sum_{i=1}^{15} [P_i(H+H_i) + M_i]F_i + \left. \begin{array}{l} \text{(from col. 9, Table 2,} \\ \text{(n}_0=0, \text{ n}_1=15)) \end{array} \right\} \\
 &\quad .3 \left[\sum_{i=1}^{15} (H+H_i)F_i - \right. \left. \begin{array}{l} \text{(from col. 9, Table 2,} \\ \text{(10x coefficient of n}_0 \\ \text{for n}_1 = 15)) \end{array} \right\} \\
 &\quad \left. H \sum_{i=1}^{15} F_i \right] \left. \begin{array}{l} \text{(Sum of col. 8, Table 2)} \end{array} \right\}
 \end{aligned}$$

$$\begin{aligned}
 PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) &= \$5,937,110 + .3[2,229,190 - 134,815(9.7120)] \\
 &= 5,937,110 + 275,960 = \$6,213,070.
 \end{aligned}$$

This cost alone exceeds the total cost of the single-shift plan.

One Replacement, Three Shifts. One-shift capacity = $1/3$

(269,629) = 89,876 manhours.

Maintenance cost/year = the same as above.

Using the same notation as above, except that $H_{(1)i}$, $H_{(2)i}$, and $H_{(3)i}$ are the numbers of manhours in the first, second, and third shifts, respectively, for year i ,

$$PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) = \sum_{i=1}^{15} [H_{(1)i}(P_i) + H_{(2)i}(P_i+.3) + H_{(3)i}(P_i+.5) + M_i]F_i$$

This expression will be modified so that previous computations in

Table 2 can be used as follows:

$$\begin{aligned}
 PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) &= \sum_{i=1}^{15} [P_i (H_{(1)i} + H_{(2)i} + H_{(3)i}) + .3H_{(2)i} + .5H_{(3)i} \\
 &\quad + M_i] F_i = \sum_{i=1}^{15} [P_i (H_{(1)i} + H_{(2)i} + H_{(3)i}) \\
 &\quad + M_i] F_i + .3 \sum_{i=1}^{15} H_{(2)i} F_i + .5 \sum_{i=1}^{15} H_{(3)i} F_i
 \end{aligned}$$

For this particular case, $H_{(1)i} = H_{(2)i} = 89,876$ manhours for $i = 1, 2, \dots, 15$. Therefore, the second term in the right-hand expression above can be written as $.3H_{(2)} \sum_{i=1}^{15} F_i$.

The third term may be modified as follows:

$$\begin{aligned}
 \sum_{i=1}^{15} H_{(3)i} F_i &= \sum_{i=1}^{15} [(H_1 + H_2 + H_{(3)i}) F_i - (H_1 + H_2) F_i] \\
 &= \sum_{i=1}^{15} (H_1 + H_2 + H_{(3)i}) F_i - (H_1 + H_2) \sum_{i=1}^{15} F_i
 \end{aligned}$$

The present worth equation can now be rewritten as follows:

$$\begin{aligned}
 PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) &= \sum_{i=1}^{15} [P_i (H_1 + H_2 + H_{(3)i}) + M_i] F_i + .3H_2 \sum_{i=1}^{15} F_i \\
 &\quad + .5 \sum_{i=1}^{15} (H_1 + H_2 + H_{(3)i}) F_i - .5(H_1 + H_2) \sum_{i=1}^{15} F_i
 \end{aligned}$$

Using Table 2 as explained in the two-shift case, we obtain the following:

$$\begin{aligned}
 \text{PW} \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) &= 5,937,110 + .3(89,876)(9.7120) + .5(2,229,190) \\
 &\quad - .5(179,752)(9.7120) \\
 &= 5,937,110 + 261,863 + 1,114,595 - 872,876 \\
 &= \$6,440,692.
 \end{aligned}$$

Again, this cost alone exceeds the total cost of the single-shift plan.

Two Replacements, One Shift. The calculations for this alternative may be taken from Table 2 as follows: Assume first replacement installed at $t = 0$. Let n_{21} = number of years first replacement is used, and n_{22} = number of years second replacement is used. Obtain PW of first replacement from column of Table 2 with $n_0 = 0$, $n_1 = n_{21}$, and adjusting to $I_1 = \$136,364$. Obtain PW of second replacement from column 13 of Table 2 with $n_0 = n_{21}$, $n_1 = n_{22}$.

Table 4. Present Worth of Total Cost
(Two Replacements, One Shift)

| | 1 | 2 | 3 |
|-------|------------------------------------|------------------------------------|-------------------|
| n_1 | PW of TC for 1st Replacement | PW of TC for 2nd Replacement | Total PW 1 + 2 |
| 1 | 455,945 | 5,566,247 | 6,022,192 |
| 2 | 883,892 | 5,064,908 | 5,948,800 |
| 3 | 1,305,567 | 4,582,777 | 5,888,344 |
| 4 | 1,720,324 | 4,119,914 | 5,840,238 |
| 5 | 2,127,606 | 3,675,279 | 5,802,885 |
| 6 | 2,526,576 | 3,252,904 | 5,779,480 |

Table 4. Present Worth of Total Cost
(Two Replacements, One Shift)
(Continued)

| | 1 | 2 | 3 |
|-------|------------------------------------|------------------------------------|-------------------|
| n_1 | PW of TC for 1st Replacement | PW of TC for 2nd Replacement | Total PW 1 + 2 |
| 7 | 2,926,519 | 2,843,085 | 5,769,604 |
| 8 | 3,318,659 | 2,450,314 | 5,768,973 ← |
| 9 | 3,713,018 | 2,067,023 | 5,780,041 |
| 10 | 4,101,651 | 1,701,775 | 5,803,426 |
| 11 | 4,497,541 | 1,344,804 | 5,842,345 |
| 12 | 4,893,706 | 997,035 | 5,890,741 |
| 13 | 5,290,712 | 658,236 | 5,948,948 |
| 14 | 5,688,531 | 329,246 | 6,017,777 |
| 15 | 6,067,784 | 0 | 6,067,748 |

The optimal solution in this case is the installation of the second replacement after the eighth year.

Two Replacements, Two Shifts. The following estimates are required in order to evaluate this alternative:

Cost of renovation = $1/2$ (\$136,364) = \$68,182
and new facilities for 1st replacement, and

= $1/2$ (\$150,000) = \$75,000
for 2nd replacement.

Salvage value = $1/2$ of salvage value for single-shift.

One-shift capacity = $1/2$ (269,629) = 134,815 manhours = H.

Maintenance cost/year = the same as for single shift.

The present worth of total labor and maintenance costs for the first machine for n years may be expressed as follows: (using notation from one replacement case)

$$PW \left(\begin{array}{l} \text{labor and main-} \\ \text{tenance costs} \end{array} \right) = \sum_{i=1}^n [H(P_i) + H_i(P_i + .3) + M_i] F_i =$$

$$\underbrace{\sum_{i=1}^n [P_i(H+H_i) + M_i] F_i}_{T_{11}; \text{ from col. 9, Table 2, } (n_0=0)} +$$

$$\underbrace{.3 \left[\sum_{i=1}^n (H+H_i) F_i \right]}_{T_{12}; \text{ from col. 9, Table 2, } (10 \times \text{coef-} \\ \text{ficient of } n_0)} - \underbrace{H \sum_{i=1}^n F_i}_{T_{13}; \text{ Sum of col. 8, Table 2}}$$

Since the second replacement begins operation later than 1970, the first term of the right-hand side of the above expression is computed using the appropriate values of n_0 . The other terms are the same as above. Table 5 shows the present worth computations for this case. The optimal solution is to install the second replacement after seven years.

Two Replacements, Three Shifts. The cost of renovation and new facilities is $1/3(\$136,364) = \$45,455$ for the first replacement and $1/3(\$150,000) = \$50,000$ for the second replacement.

Salvage value = $1/3$ of salvage value for single-shift.

One-shift capacity = $1/3(269,629) = 89,876$ manhours.

Maintenance cost/year = the same as for single-shift.

Compare labor cost during the first year with that of the two-shift operation:

$$\begin{array}{rcl}
 3\text{-shifts--}89,876(2.00) + 89,876(2.30) + & & \\
 38,648(2.50) & = & \$438,087 \\
 \\
 2\text{-shifts--}134,815(2.00) + 83,585(2.30) & = & \underline{461,876} \\
 & & \underline{\underline{\$ 21,211}}
 \end{array}$$

Since the savings in facility costs by going to 3 shifts instead of 2 shifts is less than $(68,182-45,455) + (75,000-50,000) = \$47,727$, it is obvious that the increased labor cost for the 15-year period will result in a higher total cost for 3 shifts.

The above analysis indicates that new laundry facilities should be installed at the time the addition to the hospital is constructed, and that a one-shift operation would be most economical. Also, the estimates indicate that a second replacement should be made after eight years.

Industrial and Systems Engineering

The industrial engineer is well suited to play a significant role in health facilities planning, both by virtue of his academic training and his professional interests. His academic training usually includes subjects which are directly related to facilities planning, such as plant layout and materials handling. Many of his other academic subjects relate to facilities planning as one of their primary areas of application, e.g., methods improvement, simulation, economic analysis, systems design, methods design, job design, workplace design, and equipment selection. In regard to professional practice, many industrial engineers perform projects in these same areas and in others

Table 5. Present Worth of Total Costs (Two Replacements, Two Shifts)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|-------|--------|-------------------|-----------|-----------|----------|------------------------|------------------------------|-------|--------|-------------------|----------------|---------------------------------------|----------------------------------|---------------------------|-----------|
| n_1 | I_1 | PW of S_{1j} | T_{11} | T_{12} | T_{13} | $.3[T_{12} - HT_{13}]$ | Total PW of Replacement 1 | n_2 | I_2 | PW of S_{2j} | PW of T_{21} | PW(n_1) $.3[T_{12} - HT_{13}]$ | PW (0) $.3[T_{12} - HT_{13}]$ | Total PW of Repl. 2 | Total PW |
| 1 | 68,182 | 56,604 | 419,153 | 206,040 | .9434 | 23,657 | 454,388 | 14 | 70,755 | 3,129 | 5,430,996 | 259,082 | 244,418 | 5,743,040 | 6,197,428 |
| 2 | 68,182 | 50,062 | 834,017 | 400,410 | 1.8334 | 45,972 | 898,109 | 13 | 66,750 | 6,258 | 4,943,925 | 242,263 | 215,614 | 5,220,031 | 6,118,140 |
| 3 | 68,182 | 44,079 | 1,243,725 | 583,780 | 2.6730 | 67,026 | 1,334,854 | 12 | 62,970 | 9,388 | 4,475,614 | 225,509 | 189,337 | 4,718,533 | 6,053,387 |
| 4 | 68,182 | 38,615 | 1,647,554 | 756,780 | 3.4651 | 86,890 | 1,764,011 | 11 | 59,408 | 12,518 | 4,026,134 | 208,814 | 165,402 | 4,238,426 | 6,002,437 |
| 5 | 68,182 | 33,626 | 2,044,863 | 919,990 | 4.2124 | 105,629 | 2,185,048 | 10 | 56,048 | 15,648 | 3,594,480 | 192,192 | 143,625 | 3,778,505 | 5,963,553 |
| 6 | 68,182 | 31,725 | 2,440,026 | 1,075,520 | 4.9174 | 123,774 | 2,600,257 | 9 | 52,875 | 15,637 | 3,178,431 | 175,437 | 123,683 | 3,339,352 | 5,939,609 |
| 7 | 68,182 | 27,435 | 2,831,390 | 1,223,740 | 5.5825 | 141,341 | 3,013,478 | 8 | 49,883 | 17,213 | 2,777,749 | 158,566 | 105,462 | 2,915,881 | 5,929,359 |
| 8 | 68,182 | 25,880 | 3,220,420 | 1,365,740 | 6.2099 | 158,566 | 3,421,288 | 7 | 47,055 | 17,213 | 2,390,634 | 141,341 | 88,677 | 2,509,153 | 5,930,441 |
| 9 | 68,182 | 22,181 | 3,607,381 | 1,501,720 | 6.8014 | 175,437 | 3,828,819 | 6 | 44,363 | 18,765 | 2,015,828 | 123,774 | 73,212 | 2,114,638 | 5,943,457 |
| 10 | 68,182 | 20,940 | 3,993,531 | 1,632,850 | 7.3598 | 192,192 | 4,232,965 | 5 | 41,880 | 18,777 | 1,655,574 | 105,629 | 58,983 | 1,737,660 | 5,970,625 |
| 11 | 68,182 | 15,804 | 4,379,149 | 1,759,280 | 7.8866 | 208,814 | 4,640,341 | 4 | 39,510 | 20,342 | 1,306,470 | 86,890 | 45,774 | 1,371,412 | 6,011,753 |
| 12 | 68,182 | 11,182 | 4,766,071 | 1,881,930 | 8.3836 | 225,509 | 5,048,580 | 3 | 37,275 | 21,907 | 966,298 | 67,026 | 33,312 | 1,014,978 | 6,063,558 |
| 13 | 68,182 | 7,032 | 5,154,776 | 2,000,980 | 8.8524 | 242,263 | 5,458,189 | 2 | 35,160 | 23,469 | 635,013 | 45,972 | 21,552 | 668,256 | 6,126,445 |
| 14 | 68,182 | 3,317 | 5,545,166 | 2,116,670 | 9.2947 | 259,082 | 5,869,113 | 1 | 33,173 | 25,036 | 312,975 | 23,657 | 10,463 | 331,575 | 6,200,688 |
| 15 | 68,182 | 2,845 | 5,937,110 | 2,229,190 | 9.7120 | 275,960 | 6,278,407 | 0 | | | | | | 0 | 6,278,407 |

that relate directly to facilities planning, e.g., the economic justification of capital expenditures for equipment and the design of production lines and production processes.

Obviously, there are numerous ways in which the field of industrial engineering can, does, and will contribute to the general body of knowledge regarding health facilities planning and design. This occurs through research, teaching, consulting, and practice. While this study has discussed aspects of the subject "health facilities planning" which have implications for any of these forms of contribution, it has focused primarily on the IE as a member of the institution's planning team, or as a member of the staff of the institution for which facilities are being planned.

There are many important characteristics of the process of health facilities planning and the environment in which it takes place which shape and influence the opportunities and the potentials for the IE's involvement and contribution, and characteristics of which he should be aware in order to plan his own approach to this area of application. Many of these have been discussed in previous chapters; others will be summarized in the next section of this chapter.

Figure 15 shows the various types of potential contributions of the industrial engineer through his role in the institution's facilities planning process. During the early phases of planning the industrial engineer can assist in general and technical staff work and provide consultation regarding operational objectives and the operational implications of other objectives. The staff work might include the

development of project management networks and providing assistance in functional programming, organizational studies, staffing studies, and the development of decision flow diagrams. The IE can begin to study present operations to identify deficiencies, develop ideas for improvement, develop data and information needed for planning, and to develop flow-process descriptions of major present operations and systems.

| INSTITUTIONAL PLANNING | IE'S ROLE | ARCHITECT'S ROLE | ETC. |
|--------------------------------------|---------------------------------|---------------------------------|------|
| <u>Planning</u> | | | |
| Establish Objectives | Consultation and Staff Work | Evaluating Facility Needs | |
| Organize | Study Present Operations | Design Concepts and Sketches | |
| Develop Program Plans | Projections | Feasibility Studies | |
| <u>Design</u> | | | |
| Master Facilities Plan | Systems Analysis and O.R. | Architectural Program | |
| Operational and Systems Planning | Traditional I.E. | "Hardware" Systems Selection | |
| Architectural Planning and Design | Systems Selection and Design | Drawings and Cost Estimate | |

Figure 15. The IE's Role in the Planning Process

He might also assist in making planning projections, especially of future demands and critical operational variables, and in anticipating the implications of technological changes.

As the process moves into the design phase, the engineer will find opportunities for the application of systems analysis and operations research techniques in the comparison of alternatives, the allocation of resources, and providing information for decision making under uncertainty and risk. Many of the more traditional functions of the industrial engineer will be basic to the facilities design process, e.g., layout, methods, design, staffing, and equipment selection. There will also be opportunities for the engineer to contribute to the selection and design of operational systems, such as those for material handling, communication and data processing, and supply.

General Considerations Regarding the Application of Management Science

The above sections show a few of the types of planning problems to which the quantitative analytical methods of management science might be applied. While there are many other types of problems involved in this planning process to which quantitative/analytical methods might be applied, it should be obvious that there are significant problems for which these methods are not appropriate or are not available. Also, there are many practical limitations which restrict the use of quantitative/analytical methods even where their theoretical structure might otherwise be suitable.

First, many numerical measures and estimates are required for the

use of quantitative methods. In many planning problems these measures and estimates are either not available or are obtainable only at considerable expense. This is especially true in the health field since good managerial and operational information are often lacking; in most cases even basic cost accounting information is not available.

Another limitation on the usefulness of available management science techniques in planning situations is the relatively small number of variables which can be handled in any one model. Usually planning problems involve a large number of interacting variables which must be considered simultaneously. Many of the interrelationships among variables which would need to be included in a comprehensive quantitative model probably will not be known. Also, some of the interrelationships will depend upon the decisions of the managers whom the quantitative model is supposed to benefit, presenting a problem of circular search. In such situations the decision makers will have to understand the analytical methodology and take an active part in it.

Most planning problems involve significant intangible variables, i.e., variables for which there are no quantitative or objective measures. Where intangible factors are predominant, quantitative methods may be of little use. For example, the determination of an optimal solution relative to two variables of a ten variable problem, the others of which cannot be quantitatively or objectively measured and analyzed, may add little if any valuable information to the decision regarding a long-range or strategic planning problem.

There are also many factors which affect the decision maker's

perceived probability of successful application and consequently the expected value to be derived from application attempts. These are important considerations since the costs of applying most quantitative methods are relatively high. Some of these factors will be discussed briefly.

In most cases quantitative techniques identify an optimal strategy, with the implied assumption that tactics for carrying out that strategy will be available. The decision maker must consider the validity of this assumption when he is a priori considering the potential of quantitative methods.

Lack of certainty adds another dimension to the problem of the decision maker. Since quantitative techniques usually cannot select an optimal decision for all possible occurrences, the decision maker must select an appropriate decision criterion to apply to the situation. His approach to the problems of uncertainty and risk may affect the potential and the selection of quantitative methods.

A decision maker's willingness to accept the results of analytical solutions may also depend upon the degree of reversibility of the solution. Other forms of validation of the solution may be required if the decision is extremely difficult or expensive to reverse.

The expected degree of permanence of the solution relative to changes in states of nature may affect whether and how the decision maker implements the solution. This factor involves consideration of uncertainty and flexibility, which may not be fully reflected in the analytical model.

The decision maker's degree of belief, or faith, in the solution produced by a quantitative model will affect his attitude toward its implementation. Since the decision maker must consider the whole problem, his degree of belief in a particular analytical solution may depend upon how many factors were included in the model and the investigation. The larger the number of factors that are effectively incorporated into the model the greater his confidence in the solution is likely to be.

His faith in the quantitative/analytical solution will of course also depend upon his satisfaction with the decision criteria and the pay-off measures used with the model to find the "optimal" solution. There are often many possible decision criteria, and those actually used will vary among decision makers. Management science models usually require quantitative decision criteria; the decision maker may not always be willing to accept these as satisfactory search guides in problem situations involving important intangible factors.

Another important consideration is the matter of the assumptions required by the analytical model. The decision maker must be willing to accept these assumptions as valid in order to have faith in the solution.

The sensitivity of the solution to errors in estimation and prediction will, if known, probably affect the decision maker's attitude toward implementing the analytical solution. The greater the sensitivity, the lower the degree of belief.

Finally, the confidence a decision maker has in implementing a given solution will depend upon his ability to control the process involved. The greater his control over the situation, the more willing he will be to implement the solution. There are two kinds of control with which he will be concerned. The first is the decision maker's control over his own resources, and his ability to use them to implement the solution. The second has to do with uncertainty regarding future states of nature, and the variation in solutions (strategies) regarding their "control" over outcomes under the various possible states of nature. The decision maker may prefer a less "optimal" (e.g., "optimal" might mean highest expected value) solution which offers more "control" (e.g., less variability in possible outcomes).

As mentioned earlier in this paper, the field of management science has given relatively little attention to the general problem of long-range and strategic planning but rather has concentrated primarily on policy problems. The absence of management science in the particular planning process under study should not be surprising, especially in view of the special difficulties involved. These difficulties include the effects of numerous intangibles, the lack of a clear and guiding economic rationale, the lack of clear and consistent objectives, the lack of quantitative measures of effectiveness, and the lack of good managerial information, even on present operations. Some of the primary needs involve good, basic management, organizational arrangements, and leadership. The development of the *art* of management relative to this planning process must precede the development and application of

management science techniques. Until this art is developed and practiced management science applications will be limited and specialized and will not be central and vital in the planning process.

Previous applications of management science in this process were noted in Chapter II. These were directed toward rather specialized aspects of facility design rather than the planning process itself. Within the last few years several more ambitious projects have been undertaken. Some of these involve the simulation of traffic and patient flow processes.⁸ Others involve the simulation of a medical school academic process in order to reveal the resource implications of alternative plans.⁹ Still another involves providing industrial engineering staff consultants to the planning committees of a large medical teaching complex.¹⁰ None of these projects has been completed and reported.

In spite of the difficulties there are many aspects of planning for clinical education facilities to which management science techniques can be helpful. Some of these have been indicated above. The real question from a practical point of view is how management science resources can be integrated into the planning process and brought to bear on the right problems at the right times. The considerations involved in this question are actually the subject of this paper, although it should be apparent by now that no clear and definite answers exist. Let us

⁸ Rosenbloom, Arnold, Ph.D., "Systems Applications to Health Care Delivery Systems," *The Recognition of Systems in Health Service*, Proceedings of the Symposium on Health, Health Applications Section, Operations Research Society of America, May 14-16, 1969, Washington, D.C., pp. 277-291.

⁹ The Completed work at the University of Toronto and Stanford University have not yet been published.

¹⁰ This activity at the University of Wisconsin has not yet been reported in the literature.

view this question once more from the points-of-view of the three main sources of management science capabilities for this planning process, i.e., internal technical staff, consultants, and manufacturers and suppliers.

The first source to be considered is staff planners, i.e., full-time technical specialists employed by the institution in a staff capacity to perform certain planning functions. The term "staff" means that these personnel are not performing in a role of responsibility for some functional or operational organizational unit, but rather are performing supplemental tasks at the request of line managers to support the decisions and plans which they must make. The technical staff specialists usually perform jobs which involve investigation, analysis, design, or consultation on problems or questions which relate to their fields of special competence.

The kind of staff specialist with which we are concerned here is the specialist in management science, i.e., the industrial engineer, systems engineer, operations researcher, etc.¹¹ These types of specialists can be helpful in certain phases of both the planning *for* and the planning *of* clinical education facilities if they are integrated properly into the process and if other critical needs of the planning process are recognized and fulfilled. In order to effectively participate in and contribute to this planning process the analyst will need to be familiar with the operations of the institution, particularly the hospital and

¹¹ Hereafter this type of specialist planner will be referred to as an "analyst."

clinical training programs. This familiarity is necessary in order to make good judgments regarding such things as timing, precision, and the selection of techniques.

Because of the many complexities of the planning process, including its political nature, the time is often very short between the crystalization of problem definitions susceptible to management science approaches and the deadline for decisions. Managers usually cannot predict the approaches that the analysts will want to take and the information that they will need. Therefore, the analysts should be familiar enough with the operations and the planning process to anticipate problems in time to make meaningful contributions without serious delays to the planning process. Also, they must be perceptive enough to select significant and critical problems which they can handle and for which they have time to gather information and to develop solutions.

Because of the infinite number of problems in this planning process to which management science theoretically might make some contribution, the analysts must be able to exercise careful judgment in the selection of those on which they will work. This critical problem in resource allocation requires considerable insight into the planning process and its characteristics. In order to justify to management the expense and time required for their work, the analysts must be willing to perform the preliminary investigative work in a problem area necessary to reveal the need for analysis or design and the potential of their suggested approach or technique.

One major difficulty in this connection is the tendency to fall into the role of challenger to the planner who would normally be making a particular decision without the assistance of management science. A great deal of insight into the nature of the problem and of the planning process may be required of the analyst in order to make the decision maker aware of the need for and the potential of management science techniques so that he will request or welcome assistance, which is the best, and many times the only, way to effectively contribute to the decision making process.

Another reason for the analyst to understand the planning process is that he must make judgments regarding the precision needed in analysis and problem solutions. He must understand the level of precision needed at each phase of the process and be aware of the limitations of his data so that appropriate approaches and techniques can be chosen.

It should be apparent at this point that even the management scientist, whose approach is supposed to be objective, must exercise a considerable amount of judgment in order to effectively contribute to the process of planning for clinical education facilities. To make these judgments regarding timing, selection, and precision, and to make all of the assumptions required for the application of management science models and techniques, a multidisciplinary approach is required. This means that the analyst may have to spend a great deal of time familiarizing himself with the planning process and familiarizing others with the approaches, techniques, and potentials of management science.

There are several ways in which the techniques of management science are helpful in project management. One way is through the use of network techniques such as CPM and PERT. The potential usefulness of these techniques has been suggested in previous sections of this paper. In general, the "systems approach" is needed in identifying the major components of the process, their inputs and outputs, the objectives of each component or sub-system, measures of performance, priorities, etc., and in establishing organizational arrangements, schedules, and procedures for the planning process.

The technical staff specialist who is integrally involved in the planning process will find many opportunities to use the techniques and approaches of management sciences on various limited and special problems in the planning and design process. Included in the tools used will be some of those illustrated earlier in this chapter plus other more basic techniques such as flow charting and economic comparison of alternatives. Although, as previously mentioned there are many limitations on the use of these tools, they will be helpful in providing partial answers, insights, and guidance.

Many of the model formulations of management science can also be used in the conceptual structuring of some of the larger problem areas in planning to provide a guide and an approach to the problems even if the models are not actually fully implemented. These conceptualizations can improve the many judgments which are necessary.

The well-trained analyst can contribute to the planning effort by providing general consultation in matters of productivity and efficiency,

assistance in the generation and evaluation of information for decision making, assistance in the evaluation of alternatives and proposals (especially those of equipment manufacturers), and through the development of performance specifications as bases for design by architects, manufacturers, and vendors. He can also be instrumental in the design of those "software" management systems which must be developed by the institution itself.

While the management science staff specialist will probably be involved in a wide range of activities, there are several qualifications and limitations which should be recognized. First, the internal staff specialist is not likely to be involved in equipment design; manufacturers are more capable and have better resources to do this kind of work. Although he may be involved in certain phases of internal layout and workplace design, he must work closely with the responsible architect. Also, if he is not qualified as a general hospital consultant, he should be careful not to create the impression that he is. The characteristics and roles of these consultants will be discussed later.

There are other difficulties and problems in realizing the potential of management science staff specialists at this point in time. First, there is an extreme shortage of management science specialists, industrial and systems engineers in particular, in the health field. Very few of those in the field have experience in hospital facilities design, much less clinical education facilities. Also, it seems that most of the industrial and systems engineers who practice in the health field do not specialize in any particular operational process or

department of the hospital, but rather perform general types of management analyses covering many hospital departments. Since they are not process specialists, it is difficult for them to play a significant role in the planning and design of functional areas without extensive analysis, investigation, and study. Consequently, cost and schedule limitations often do not permit their participation in any significant manner.

The analyst should be aware of the possibility of "oversell" regarding management science approaches and techniques. Those who do not understand its potentiality and its limitations may be "oversold" by the sophistication and seemingly "all-encompassing" terminology and methodology of management science. This is another reason that the analyst must indoctrinate the other planners and the managers on the techniques and approaches of management science.

Analysis, while important and necessary, may play a secondary role to creativity and design in the planning of clinical education facilities. Since most of his tools and techniques are analysis oriented, the management scientist may find that he must modify his traditional approaches towards multidisciplinary involvement and towards more general (less mathematical) forms of analysis and design in order to assume more than a minor role in the process.

The influence of intangible factors in many planning problems may be so overriding that quantitative/analytical methods would have little impact. Even where this is not the case, managers would have to be involved in the analytical process to assist in stating objectives,

selecting criteria, validating assumptions, and making trade-offs in the selection among alternatives. When accurate data are difficult or impossible to obtain, and when the model solution is very sensitive to the set of assumptions chosen from all feasible assumptions, the manager may tend to depend more heavily upon other criteria such as politics, expediency, rule-of-thumb, safety, and popularity, than upon the results of formal analytical methods.

Another limitation is that most management science techniques are based upon marginal analysis and, with the possible exception of linear programming, are restricted to the simultaneous evaluation of one or at most a very few variables. In planning and design, the number of variables involved and the ranges of their possible values make it difficult to define marginal values, much less evaluate them; many variables must be considered simultaneously. While limited-variable marginal analysis is helpful, and possibly necessary, its usefulness comes late in the process, after feasible alternatives have been formulated. Even then, a great deal of judgment and understanding of the probable operations of each alternative are required along with the results of quantitative analysis in order to perform a comprehensive evaluation and selection.

Due to the above complexities and difficulties, much of the planning and design activity involves a search for any operational and acceptable system with little regard for whether or not it is optimal in the quantitative/analytic sense.

Other sources, although indirect, of management science capability are the manufacturers and suppliers of equipment and furnishings

for buildings. Although this capability is employed primarily in equipment design, selection, and installation, in many cases rather extensive operational analysis is required in order to develop an effectively functioning system. These companies are capable of bringing specialized knowledge and experience from other locations to bear on the planning and design problems at a given institution. Ideally, competitive companies should be asked to propose systems to satisfy "performance specifications" developed by the institution and its consultants. These proposals, which should include feasibility analyses, then should be thoroughly evaluated by the institution prior to selecting from among them. The internal technical staff would play a key role in this evaluation and selection.

Consultants are a third and important source of management science capability for the institution involved in an extensive planning endeavor. Consultant firms offer several advantages. They can provide a pool of technical manpower to meet sporadic and varying demands. In some cases they may have a more creditable base for objectivity; the internal staff might be considered parochial or as having reason for bias. Consultant firms usually have specialists in various fields of knowledge among their staff upon which they can call if needed. They are often able to transfer experience and knowledge from other jobs to an application for the customer institution. Like the internal technical staff, they should be especially helpful in evaluating alternative plans, designs, and methods.

It should be obvious, however, that outside consultants require a

great deal of internal effort if their work is to be effective. Their assignments should be well planned and specified in as much detail as is practical so that their efforts fit within and complement the internal planning process. The entire planning framework, including objectives, criteria, constraints, and assumptions, should be specified for them by the internal planners. The internal planning staff should be capable of following, understanding, and evaluating the consultants' work so that the results can be successfully implemented and so that the essential and valuable aspects of their experience and analysis are retained within the institution for future use.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

The purposes of this study were to investigate the process of planning clinical facilities for medical education through the systems approach, and to investigate the applicability of management science principles, approaches, and techniques in this process. Sources of information for this investigation included actual experience in planning for a new clinical services building at the Medical College of Georgia, accounts of other planning efforts for similar projects reported in the literature and by discussions with professional people working in this field, and a review of corporate and managerial planning literature. The nature of this research was essentially exploratory and descriptive, and it was intended to establish a clarification of the concept of planning and a basis for understanding the planning process. Conclusions and recommendations relative to each of the three primary objectives stated in Chapter I are contained in the following sections.

The Planning Process

The first objective of this research was the development of a description and conceptualization of the process of planning for clinical facilities for medical education. The process was described in terms of the types of planning involved, the nature of the process,

steps required, management of the process, approaches and methods, behavioral considerations, organizational arrangements, and certain other considerations in health facilities planning. In addition, the process was further conceptualized by the development of flow diagrams of planning activity and by the development of illustrative decision problems to which management science techniques might be applied. Therefore, it is concluded that the first objective has been satisfactorily accomplished.

The concepts and findings from other fields of planning were found to be applicable and useful in describing and understanding the process of institutional planning for clinical education programs and facilities. This particular process was found to be a complex one which must be integrated with comprehensive institutional planning. Many of the difficulties involved in the process relate to a lack of appreciation and knowledge of planning, the inherent complexity of the health field, the characteristics of academic institutions, the multiple objectives of health education institutions, and the lack of good measures of the degree of attainment of these objectives. There is a need for increased attention to this field by institutional management. In addition to the need for applied research in the management sciences, there are also many aspects of the process which need researching by behavioral scientists.

Applicability and Practicability of Management Science

The second objective was an investigation of the applicability and practicability of management science principles and techniques

through an analysis of the planning decision process, and the development of examples of the application of management science techniques. Based upon the description and conceptualization, it is concluded that the principles and techniques of management science are theoretically applicable to many areas of the process of planning for clinical education facilities. Several illustrations and arguments were provided in Chapter VIII in support of this conclusion. There are several critical variables which affect the practicability of the use of management science in this process at this time. These include a general lack of understanding of the planning process by most management scientists and a lack of understanding of management science by the managers of the process, timing requirements, characteristics of the planning framework, politics, intangibles, the difficulty of selecting appropriate projects, data, uncertainty, and a critical need for other more basic improvements in the planning process, such as improved managerial planning.

It is concluded that the most promising forms of management science contribution to this planning process are the following:

1. Qualitative (both descriptive and normative) study and modeling of the process. The purpose of this form of contribution would be to provide a better understanding of the process, to provide a systematic approach to the planning process, to provide a general design methodology, and to provide a framework for other forms of management science contribution.

2. The use of quantitative analytical models in certain aspects of facilities planning and design such as the selection of capacities

for certain functional units which must serve stochastic demand, and the economic evaluation of alternative facilities and operational systems.

3. The use of computer simulation in the evaluation of facility designs and operational systems and in predicting the consequences of alternative policy decisions.

4. The use of traditional industrial and systems engineering techniques and approaches in the design and selection of operational systems and facility layouts.

5. The use of computerized planning models for fast and efficient computations and for providing quick access to relevant data banks.

6. Providing technical staff work, e.g., developing project activity networks, and providing general consultation to the planning team regarding operational systems and methods.

Suggested Areas for Further Research

The third objective of this research was the identification of promising and important areas of the planning process which require further research and development regarding the application of management science. It is apparent that many management science techniques are applicable in theoretical concept to the process of planning clinical facilities for medical education. This study has revealed the need for *applied* research in this area. While almost all forms of research listed on page 77 are needed, the most urgently needed forms involve the application of management science methods and techniques to new problems

areas, the study of data requirements and data availability, the development of new models, and further study of the planning process itself and the implications of its characteristics for the application of management science approaches and techniques, the area in which the present research has made a contribution. These forms of needed research are described below:

1. The development of systems models of the health educational, research, and patient-care processes. These models would reflect and describe the various components of the processes and their interrelationships. They could be used to provide a systematic framework for analysis and for planning. They could also benefit the management of the planning process by facilitating communications and decision making.

2. The development of computer simulation models. These might be similar to the models indicated in 1 above, but would be constructed to represent the dynamic operational characteristics of the systems. They would probably be more limited and more precise in an operational sense. These simulation models could be used to test alternative plans and designs and to identify sensitive variables in the planning process. They could also be used to predict the results of alternative decisions.

3. The development of micro-economic models relative to this type of institution similar to those of the "Theory-of-the-Firm." Such models would be helpful as guides for decision making throughout the planning process by revealing the economic implications of decisions.

4. The development of special computer planning models. These models might incorporate all of the above types and thereby provide

efficient and effective methodologies for evaluating alternative plans and searching for improved alternatives. They also might provide quick access to large data banks.

5. Further research on the planning process itself. This research would focus on the nature and characteristics of this particular planning process and ways of improving it. Several types of research are needed in this category. For example, additional research is needed in the actual application of management science techniques and approaches. Data and information requirements for planning should be identified and studied. Studies should be made to determine the characteristics of organizational arrangements required for this type of planning process. Alternative activity networks and schedules for this planning process should be developed and studied. Decision flow diagrams should be developed as guides to the planning and design process. Finally, there should be further descriptive analysis of the various phases of the planning process, e.g., the architectural design phase.

6. Planning for flexibility. Research should be performed on ways of achieving flexibility in the planning process as well as in the resultant facilities. For example, methods should be developed for evaluating alternative facility plans in terms of their flexibility. In addition to the development of evaluation models, research might be performed for the development of decision models and specific design characteristics which emphasize flexibility.

7. The development of methods for generating and using planning data. This might include such things as the establishment of planning data banks, studying the special data requirements of this planning process, developing ways of using existing data, and evaluating the validity and reliability of existing data.

8. The development and the application of methodologies for evaluating alternative operational systems. The evaluation should be in terms of economic and other measurable criteria as well as intangible factors. Simulation will probably be one of the most useful techniques in these methodologies. Examples of operational systems to which methodologies should be applied include material handling, information, supply, and support systems.

9. Forecasting and anticipating the future. Since long-range facilities planning must be performed within the context of forecasts and anticipations regarding the future, the development of improved methods for doing this is most important. Various types of methods are needed, including quantitative techniques, technological forecasting, "expert" and group judgment approaches, and methods for the evaluation of planning assumptions.

10. The further development and application of an improved general design methodology and approach for planning and designing health facilities. The methodology should include the development of performance specifications, the identification and measurement of critical design variables, and the use of cost-benefit analysis throughout the process.

11. Experimentation with facility designs. More research should be devoted to actual trials and systematic evaluation of alternative designs for clinical education facilities. The results should be reported in a form useful to others involved in planning and design projects.

General Conclusions

The planning of clinical facilities for medical education, and indeed health facilities planning in general, has been found to be a fertile field for further work, both research and actual applications. This field, however, is not like other fields of more traditional interest to the industrial and systems engineering researcher and academician wherein sufficient insights, understanding, and motivation are obtained through courses, text examples, personal contacts, journals, and consulting experience. Research of the present type, descriptive and conceptual in orientation, was needed in order to provide a background for the more scientific, tightly structured, in-depth forms of research. It is hoped that the present investigation will serve as a foundation for such further work.

The author feels that the special challenges of this planning process to management science will be met, both because of the importance of the problems involved and because of the potential for management science to contribute increased rationalism to the process.

VITA

James Bailey Mathews was born November 1, 1938, at Dawson (Terrell County), Georgia, to Mansfield Edwin and Kathryn Christine (née Bailey) Mathews. He attended public schools in Terrell County, graduating from Terrell County High School in June, 1956.

He entered the Georgia Institute of Technology in September, 1956, as a Co-operative student. His first work quarter was with the Jacksonville Naval Air Station, Jacksonville, Florida, and subsequent work quarters were with the Georgia Power Company, Columbus, Georgia. While in undergraduate school he was active in the Toastmasters Club, YMCA, Arnold Air Society, American Institute of Industrial Engineers, and the Alpha Tau Omega social fraternity. His undergraduate honors included Alpha Pi Mu, Who's Who, Phi Kappa Phi, Tau Beta Pi, outstanding IE Graduate—1961, and the Georgia Tech Honor Award (AF ROTC). He received a Goodyear scholarship for his senior year. He graduated in June, 1961, with the degree Bachelor of Industrial Engineering, Co-operative Plan, with Highest Honor.

After graduation, Mr. Mathews joined the DuPont Company in Kinston, N. C., as an Industrial Engineer. In October, 1961, he entered the United States Air Force as a Second Lieutenant to fulfill the commitment made through the R.O.T.C. at Georgia Tech. He served three years as a Production/Procurement officer at Headquarters, Middletown Air Material Area, Olmsted AFB, Middletown, Pennsylvania. He was

made a Contracting Officer, responsible for negotiating contracts with firms for the overhaul, repair, and modification of aircraft and missiles. Mr. Mathews was awarded the Air Force Commendation Medal and was honorably discharged from the Air Force in September, 1964, with the rank of First Lieutenant.

On January 14, 1962, while in the Air Force, Mr. Mathews married Ann Chappel Davidson of Dawson, Georgia.

Mr. Mathews entered the Graduate School of Industrial Engineering at the Georgia Institute of Technology in September, 1964, with a National Science Foundation fellowship with the intention of pursuing a Doctor of Philosophy degree. He joined the Hospital Systems Research Group as a Research Assistant. He received the degree of Master of Science in Industrial Engineering in June, 1966. His Master's research was entitled "The Use of ANOVA and Regression Techniques in the Investigation of Decision Determinants" (applied to hospital administration). He continued his doctoral program with the assistance of a Public Health Service fellowship through December, 1966. During this portion of his graduate education Mr. Mathews gained experience teaching in the School of Industrial Engineering and in a hospital management analyst training program.

In January, 1967, subsequent to the completion of his formal coursework and comprehensive examinations, Mr. Mathews was given the opportunity to join a collaborative effort between Georgia Tech and the Medical College of Georgia involving the planning and design of new clinical service facilities at the Medical College. Since this

activity was related to his research interests, and since the project was to be directed by his faculty advisor, Dr. Harold E. Smalley, Mr. Mathews joined the project as a full-time Project Engineer, employed by Georgia Tech. In March, 1967, he moved to Augusta, where the project was being conducted at the Medical College of Georgia.

During 1967 and 1968 several other Industrial Engineering activities were initiated at the Medical College, including programs with the Eugene Talmadge Memorial Hospital, the School of Medicine, and the School of Dentistry, and a program of graduate training entitled "Program in Hospital and Medical Systems" sponsored by the Public Health Service and conducted jointly by Georgia Tech and the Medical College. In July, 1968, all Industrial Engineering activity at the Medical College was organized under a Division named the Program in Hospital and Medical Systems. Mr. Mathews was given a joint appointment as Assistant Professor with Georgia Tech and the Medical College, and was made Assistant Director in charge of the Program at the Medical College under the direction of Dr. Harold E. Smalley. Since July, 1968, Mr. Mathews' responsibilities and activities have included administration and supervision, program development, educational activity (under the PHMS grant), research, and engineering service projects.

Two daughters have been born while Mr. Mathews has been in Augusta, Kimberly Ann on September 13, 1967, and Jamie Christine on April 9, 1969.